Appendix A: Plant List

1. Salt-Tolerant Plants

These plant species are suitable for planting within 80 feet of a roadside that is subject to de-icing and anti-icing application of salts.

Trees

White Oak *(Quercus alba)*
Red Oak *(Quercus rubra)*
White Poplar *(Populus alba)*
Black Locust *(Robinia pseudoacacia)*
Blue Spruce *(Picea pungens)*
Green Ash *(Fraxinus pennsylvanica)*
Eastern Cottonwood *(Populus deltoides)*
Eastern White Pine (*Pinus strobus)*
Hawthorn *(Crataegus spp.)*
Pitch Pine *(Pinus rigida)*

Shrubs

Forsythia *(Forsythia x intermedia)*
Honeylocust (*Gleditsia triacanthos)*

Grasses

Birdsfoot trefoil *(Lotus corniculatus)*
Perennial ryegrass *(Lolium perenne)*
Switchgrass *(Panicum virgatum)*
Tall Fescue *(Festuca arundinacea)*
Alfalfa (*Medicago sativa)*
Cattails *(Typha domingensis)*

2. Native Plants/Xeriscaping

These plant species are native or adapted to Southern New England. Information on these species and others that may be suitable for xeriscaping may be found in the references at the end of this appendix.

Trees

Eastern Red Cedar (*Juniperus virginiana*)
Flowering Dogwood (*Cornus florida*)
Hackberry (*Celtis occidentalis)*
Hawthorns (*Crataegus spp.*)
Hickories (*Carya spp.*)
Oaks (*Quercus spp.*)
Walnuts (*Juglans spp.*)
Atlantic White Cedar (*Chamaecyparis thyoides*)

Black Spruce (*Picea mariana*)
Eastern Hemlock (*Tsuga canadensis*)
Eastern Red Cedar (*Juniperus virginiana*)
Northern White Cedar (*Thuja occidentalis*)
White Pine (*Pinus strobus*)
Black Cherry (*Prunus serotina*)
Choke Cherry (*Prunus virginiana*)
Red Mulberry (*Morus rubra*)

Shrubs

For Dry, Sunny Areas

Bayberry (*Myrica pensylvanica*)
Lowbush Blueberry (*Vaccinium augustifolium*)
Ground Juniper (*Juniperus communis*)
Jersey Tea (*Ceanothus americanus*)
Sweet Fern (*Comptonia peregrina*)

For Shaded Areas

Hazelnut (*Corylus americana, C. cornuta*)
Mountain Laurel (*Kalmia latifolia*)
Swamp Azalea (*Rhododendron viscosum*)
Viburnums (*V. acerfolium, V. cassinoides, V. alnifolium*)

For Moist Sites

Dogwoods (*Cornus spp.*)
Elderberry (*Sambucus canadensis*)
Highbush Blueberry (*Vaccinium corymbosum*)
Inkberry (*Ilex glabra*)
Pussy Willow (*Salix discolor*)
Shadbush Serviceberry (*Amelanchier canadensis*)
Spirea (*Spirea latifolia*)
Swamp azalea (*Rhododendron viscosum*)
Sweet Pepperbush (*Clethra alnifolia*)
Viburnums (*Viburnum spp.*)
Winterberry (*Ilex verticillata*)
Witch Hazel (*Hamamelis virginiana*)
Red Mulberry (*Morus rubra*)

Perennials

Wild red columbine (*Aquilegia canadensis*)
Bearberry, kinnickinick (*Arctostaphylos uva-ursi*)
Wild ginger (*Asarum canadense*)
Butterfly weed (*Asclepias tuberosa*)
White wood aster (*Aster divaricatus*)
New England aster (*Aster novae-angliae*)
Marsh marigold (*Caltha palustris*)
Wild geranium (*Geranium maculatum*)
Cardinal flower (*Lobelia cardinalis*)

Solomon's plume (*Maianthemum racemosum, syn. Smilacina racemosa*)
Partridgeberry (*Mitchella repens*)
Wild blue phlox (*Phlox divaricata*)
Bloodroot (*Sanguinaria canadensis*)
Foamflower (*Tiarella cordifolia*)
Barren strawberry *(Waldsteinia fragariodes)*

Grasses
Big bluestem *(Andropogon gerardii)*
Switchgrass *(Panicum virgatum)*
Little bluestem *(Schizachyrium scoparium, syn. Andropogon scoparius)*

3. Stormwater Ponds and Wetlands Plant List

This section contains planting guidance for stormwater ponds and wetlands. The following lists emphasize the use of plants native to Connecticut and southern New England and are intended as general guidance for planning purposes. Local landscape architects and nurseries may provide additional information, including plant availability, for specific applications.

Plantings for stormwater ponds and wetlands should be selected to be compatible with the various hydrologic zones (NYDEC, 2001) within these treatment practices. The hydrologic zones reflect the degree and duration of inundation by water. Plants recommended for a particular zone can generally tolerate the hydrologic conditions that typically exist within that zone. Table A-1 summarizes recommended plantings (trees/shrubs and herbaceous plants) within each hydrologic zone. This list is not intended to be exhaustive, but includes a number of recommended native species that are generally available from commercial nurseries. Other plant species may be acceptable if they can be shown to be appropriate for the intended hydrologic zone.

Table A-1
Plant List for Stormwater Ponds and Wetlands

Hydrologic Zone	Zone Description	Plant Name and Form	
Zone 1 **Deep Water Pool**	• 1 to 6 feet deep, permanent pool • Submergent plants (if any at all) • Not routinely planted due to limited availability of plants that can survive in this zone and potential clogging of outlet structure • Plants reduce resuspension of sediments and improve oxidation/aquatic habitat	<u>Trees and Shrubs</u> Not recommended <u>Herbaceous Plants</u> Coontail (Ceratophyllum demersum) Duckweed (Lemma sp.) Pond Weed, Sago *(Potamogeton Pectinatus)* Waterweed (*Elodea canadensis*) Wild Celery (*Valisneria Americana)*	 Submergent Submergent/Emergent Submergent Submergent Submergent
Zone 2 **Shallow Water Bench**	• 1 foot below the normal pool (aquatic bench in stormwater ponds) • Plants partially submerged • Emergent wetland plants • Plants reduce resuspension of sediments, enhance pollutant removal, and provide aquatic and nonaquatic habitat	<u>Trees and Shrubs</u> Buttonbush *(Cepahlanthus occidentalis)* <u>Herbaceous Plants</u> Arrow arum *(Peltandra virginica*) Arrowhead, Duck Potato *(Saggitaria latifolia)* Blue Flag Iris *(Iris versicolor)* Blue Joint (*Calamagrotis canadensis*) Broomsedge *(Andropogon virginicus)* Bushy Beardgrass *(Andropogon glomeratus)* Cattail *(Typha sp.)* Common Three-Square *(Scirpus pungens)* Duckweed *(Lemma sp.)* Hardstem Bulrush *(Scirpus acutus)* Giant Burreed *(Sparganium eurycarpum)* Lizard.s Tail *(Saururus cernuus)* Long-leaved Pond Weed *(Potamogeton nodosus)* Marsh Hibiscus *(Hibiscus moscheutos)* Pickerelweed *(Pontederia cordata)* Rice Cutgrass *(Leersia oryzoides)* Sedges *(Carex spp.)* Soft-stem Bulrush *(Scirpus validus)* Smartweed *(Polygonum spp)* Soft Rush *(Juncus effusus)* Spatterdock *(Nuphar luteum)* Switchgrass *(Panicum virgatum)*	 Deciduous shrub Emergent Emergent Emergent Emergent Perimeter Emergent Emergent Emergent Submergent/Emergent Emergent Emergent Emergent Rooted Submerged Aquatic Emergent Emergent Emergent Emergent Emergent Emergent Emergent Emergent Perimeter

Hydrologic Zone	Zone Description	Plant Name and Form	
		Sweet Flag *(Acorus calamus)*	Herbaceous
		Wild Rice *(Zizania aquatica)*	Emergent
		Wool Grass *(Scirpus cyperinus)*	Emergent
Zone 3 **Shoreline Fringe**	• 1 foot above the normal pool (includes safety bench of pond) • Frequently inundated if storm events are subject to extended detention • Plants must be able to withstand inundation during storms and occasional drought • Plants provide shoreline stabilization, shade the shoreline, enhance pollutant removal, and provide wildlife habitat (or selected to control overpopulation of waterfowl)	<u>Trees and Shrubs</u>	
		Arrowwood Viburrium *(Viburrium dentatum)*	Deciduous shrub
		Bald Cypress *(Taxodium distichum)*	Deciduous tree
		Black Ash *(Fraxinus nigra)*	Deciduous tree
		Black Willow *(Salix nigra)*	Deciduous tree
		Buttonbush *(Cepahlanthus occidentalis)*	Deciduous shrub
		Common Spice Bush *(Lindera benzoin)*	Deciduous shrub
		Elderberry *(Sambucus canadensis)*	Deciduous shrub
		Larch, Tamarack *(Larix latricina)*	Coniferous tree
		Pin Oak *(Quercus palustris)*	Deciduous tree
		Red Choke Berry *(Pyrus arbutifolia)*	Deciduous shrub
		Red Maple *(Acer rubrum)*	Deciduous tree
		River Birch *(Betula nigra)*	Deciduous tree
		Silky Dogwood *(Cornus amomium)*	Deciduous shrub
		Slippery Elm *(Ulnus rubra)*	Deciduous tree
		Smooth Alder *(Alnus serrulata)*	Deciduous tree
		Speckled Alder *(Alnus rugosa)*	Deciduous shrub
		Swamp White Oak *(Quercus bicolor)*	Deciduous tree
		Swamp Rose *(Rosa Palustrus)*	Deciduous shrub
		Tupelo *(Nyssa sylvatica vari biflora)*	Deciduous tree
		Winterberry *(Ilex verticillata)*	Deciduous shrub
		<u>Herbaceous Plants</u>	
		Arrow arum *(Peltandra virginica)*	Emergent
		Arrowhead, Duck Potato *(Saggitaria latifolia)*	Emergent
		Blue Flag Iris *(Iris versicolor)*	Emergent
		Blue Joint (*Calamagrotis canadensis*)	Emergent
		Blue Vervain (*Verbena hastata*)	Emergent
		Boneset (*Eupatorium perfoliatum*)	Emergent
		Broomsedge *(Andropogon virginicus)*	Perimeter
		Bushy Beardgrass *(Andropogon glomeratus)*	Emergent
		Cattail *(Typha sp.)*	Emergent
		Chufa (*Cyperus esculentus*)	Emergent
		Creeping Bentgrass (*Agrostis stolonifera*)	Emergent
		Creeping Red Fescue (*Festuca rubra*)	Emergent
		Flat-top Aster (*Aster umbellatus*)	Emergent
		Fowl Bluegrass (*Poa palustris*)	Emergent

Hydrologic Zone	Zone Description	Plant Name and Form	
		Giant Burreed *(Sparganium eurycarpum)*	Emergent
		Green Bulrush (*Scirpus atrovirens*)	Emergent
		Marsh Hibiscus *(Hibiscus moscheutos*)	Emergent
		Pickerelweed *(Pontederia cordata)*	Emergent
		Redtop (*Agrostis alba*)	Perimeter
		Rice Cutgrass *(Leersia oryzoides)*	Emergent
		Sedges *(Carex spp)*	Emergent
		Tufted Hairgrass (*Deschampsia caespitosa*)	Perimeter
		Soft-stem Bulrush *(Scirpus validus)*	Emergent
		Smartweed *(Polygonum spp.)*	Emergent
		Soft Rush *(Juncus effusus)*	Emergent
		Spotted Joe-pye weed (*Eupatorium maculatum*)	Emergent
		Swamp Aster (*Aster puniceus*)	Emergent
		Switchgrass *(Panicum virgatum)*	Perimeter
		Sweet Flag *(Acorus calamus)*	Herbaceous
		Water Plantain (*Alisma plantago-aquatica*)	Emergent
		Wild-rye (*Elymus spp.*)	Emergent
		Wool Grass *(Scirpus cyperinus)*	Emergent
Zone 4 **Riparian Fringe**	• 1 to 4 feet above the normal pool • Includes nearly all of temporary extended detention volume • Periodically inundated after storms • Plants must be able to withstand inundation during storms and occasional drought • Plants provide shoreline stabilization, shade the shoreline, enhance pollutant removal, and provide wildlife habitat (or selected to control overpopulation of waterfowl)	<u>Trees and Shrubs</u>	
		American Elm *(Ulmus americana)*	Deciduous tree
		Arrowwood Viburrium *(Viburrium dentatum)*	Deciduous shrub
		Bald Cypress *(Taxodium distichum)*	Deciduous tree
		Bayberry *(Myrica pensylvanica)*	Deciduous shrub
		Black Ash *(Fraxinus nigra)*	Deciduous tree
		Blackgum or Sourgum *(Nyssa sylvatica*)	Deciduous tree
		Black Willow *(Salix nigra)*	Deciduous tree
		Buttonbush *(Cepahlanthus occidentalis)*	Deciduous shrub
		Common Spice Bush *(Lindera benzoin)*	Deciduous shrub
		Eastern Cottonwood *(Populus deltoides)*	Deciduous tree
		Eastern Red Cedar *(Juniperus virginiana)*	Coniferous tree
		Elderberry *(Sambucus canadensis)*	Deciduous shrub
		Green Ash, Red Ash *(Fraxinus pennsylvania)*	Deciduous tree
		Larch, Tamarack *(Larix latricina)*	Coniferous tree
		Pin Oak *(Quercus palustris*)	Deciduous tree
		Red Choke Berry *(Pyrus arbutifolia)*	Deciduous shrub
		Red Maple *(Acer rubrum)*	Deciduous tree
		River Birch *(Betula nigra)*	Deciduous tree
		Shadowbush, Serviceberry *(Amelanchier Canadensis)*	Deciduous shrub
		Silky Dogwood *(Cornus amomium)*	Deciduous shrub
		Slippery Elm *(Ulnus rubra)*	Deciduous tree
		Smooth Alder *(Alnus serrulata)*	Deciduous tree
		Speckled Alder *(Alnus rugosa)*	Deciduous shrub

Hydrologic Zone	Zone Description	Plant Name and Form	
		Swamp White Oak *(Quercus bicolor*)	Deciduous tree
		Swamp Rose *(Rosa Palustrus)*	Deciduous shrub
		Sweetgum *(Liquidambar styraciflua)*	Deciduous tree
		Sycamore *(Platanus occidentalis)*	Deciduous tree
		Tulip Tree *(Liriodendron tulipifera)*	Deciduous tree
		Tupelo *(Nyssa sylvatica vari biflora)*	Deciduous tree
		Winterberry *(Ilex verticillata)*	Deciduous shrub
		Witch Hazel *(Hamamelis virginiana)*	Deciduous shrub
		<u>Herbaceous Plants</u>	
		Big Bluestem (*Andropogon gerardi)*	Perimeter
		Birdfoot deervetch (*Lotus Corniculatus*)	Perimeter
		Blue Vervain (*Verbena hastata*)	Emergent
		Boneset (*Eupatorium perfoliatum*)	Emergent
		Blue Joint (*Calamagrotis canadensis*)	Emergent
		Cardinal flower (*Lobelia cardinalis*)	Perimeter
		Chufa (*Cyperus esculentus*)	Emergent
		Fowl Bluegrass (*Poa palustris*)	Emergent
		Fowl mannagrass (*Glyceria striata*)	Perimeter
		Green Bulrush (*Scirpus atrovirens*)	Emergent
		Redtop (*Agrostis alba*)	Perimeter
		Tufted Hairgrass (*Deschampsia caespitosa*)	Perimeter
		Sedges *(Carex spp)*	Emergent
		Smartweed *(Polygonum spp.)*	Emergent
		Soft Rush *(Juncus effusus)*	Emergent
		Spotted Joe-pye weed (*Eupatorium maculatum*)	Emergent
		Swamp Aster (*Aster puniceus*)	Emergent
		Switchgrass *(Panicum virgatum)*	Perimeter
		Water Plantain (*Alisma plantago-aquatica*)	Emergent
		Wild-rye (*Elymus spp.*)	Emergent
		Water Plantain (*Alisma plantago-aquatica*)	Emergent
		Wild-rye (*Elymus spp.*)	Emergent
Zone 5 Floodplain Terrace	• Extends from the maximum channel protection water surface elevation (typically 2-yr storm) to the 100-year water surface elevation • Infrequently inundated • Plants must be able to withstand occasional, brief inundation and occasional drought conditions • Plants provide slope stabilization, shade, and wildlife habitat	<u>Trees and Shrubs</u>	
		American Elm *(Ulmus americana)*	Deciduous tree
		Bayberry *(Myrica pensylvanica)*	Deciduous shrub
		Black Ash *(Fraxinus nigra)*	Deciduous tree
		Black Cherry *(Prunus serotina)*	Deciduous tree
		Blackgum or Sourgum *(Nyssa sylvatica)*	Deciduous tree
		Black Willow *(Salix nigra)*	Deciduous tree
		Buttonbush *(Cepahlanthus occidentalis)*	Deciduous shrub
		Common Spice Bush *(Lindera benzoin)*	Deciduous shrub

Hydrologic Zone	Zone Description	Plant Name and Form	
		Eastern Cottonwood *(Populus deltoides)*	Deciduous tree
		Eastern Hemlock *(Tsuga canadensis)*	Coniferous tree
		Eastern Red Cedar *(Juniperus virginiana)*	Coniferous tree
		Elderberry *(Sambucus canadensis)*	Deciduous shrub
		Green Ash, Red Ash *(Fraxinus pennsylvania)*	Deciduous tree
		Hackenberry *(Celtis occidentalis)*	Deciduous tree
		Pin Oak *(Quercus palustris)*	Deciduous tree
		Red Choke Berry *(Pyrus arbutifolia)*	Deciduous shrub
		Red Maple *(Acer rubrum)*	Deciduous tree
		River Birch *(Betula nigra)*	Deciduous tree
		Shadowbush, Serviceberry *(Amelanchier canadensis)*	Deciduous shrub
		Silky Dogwood *(Cornus amomium)*	Deciduous shrub
		Slippery Elm *(Ulnus rubra)*	Deciduous tree
		Smooth Alder *(Alnus serrulata)*	Deciduous tree
		Swamp White Oak *(Quercus bicolor)*	Deciduous tree
		Sweetgum *(Liquidambar styraciflua)*	Deciduous tree
		Sycamore *(Platanus occidentalis)*	Deciduous tree
		Tulip Tree *(Liriodendron tulipifera)*	Deciduous tree
		Tupelo *(Nyssa sylvatica vari biflora)*	Deciduous tree
		White Ash *(Fraxinus americana)*	Deciduous tree
		Winterberry *(Ilex verticillata)*	Deciduous shrub
		Witch Hazel *(Hamamelis virginiana)*	Deciduous shrub
		<u>Herbaceous Plants</u>	
		Annual Ryegrass (*Lolium multiflorum*)	Perimeter
		Big Bluestem (*Andropogon gerardi*)	Perimeter
		Birdfoot deervetch (*Lotus Corniculatus*)	Perimeter
		Cardinal flower (*Lobelia cardinalis*)	Perimeter
		Creeping Red Fescue (*Festuca rubra*)	Perimeter
		Fowl mannagrass (*Glyceria striata*)	Perimeter
		Redtop (*Agrostis alba*)	Perimeter
		Timothy (*Phleum pratense*)	Perimeter
		Tufted Hairgrass (*Deschampsia caespitosa*)	Perimeter
		White Clover (*Trifolium repens*)	Perimeter
		Switchgrass *(Panicum virgatum)*	Perimeter
Zone 6 **Upland Slopes**	• Above the maximum 100-year water surface elev. • Typically includes outer buffer of pond or wetland • Plants should be selected based on soil condition, light, and function (not inundation since almost never inundated)	<u>Trees and Shrubs</u>	
		American Elm *(Ulmus americana)*	Deciduous tree
		Bayberry *(Myrica pensylvanica)*	Deciduous shrub
		Black Cherry *(Prunus serotina)*	Deciduous tree
		Blackgum or Sourgum *(Nyssa sylvatica)*	Deciduous tree

Hydrologic Zone	Zone Description	Plant Name and Form	
		Eastern Hemlock *(Tsuga Canadensis)*	Coniferous tree
		Eastern Red Cedar *(Juniperus virginiana)*	Coniferous tree
		Elderberry *(Sambucus canadensis)*	Deciduous shrub
		Hackenberry *(Celtis occidentalis)*	Deciduous tree
		Pin Oak *(Quercus palustris)*	Deciduous tree
		Red Maple *(Acer rubrum)*	Deciduous tree
		Shadowbush, Serviceberry *(Amelanchier canadensis)*	Deciduous shrub
		Sweetgum *(Liquidambar styraciflua)*	Deciduous tree
		Sycamore *(Platanus occidentalis)*	Deciduous tree
		Tulip Tree *(Liriodendron tulipifera)*	Deciduous tree
		White Ash *(Fraxinus Americana)*	Deciduous tree
		<u>Herbaceous Plants</u>	
		Birdfoot deervetch (*Lotus Corniculatus*)	Perimeter
		Cardinal flower (*Lobelia cardinalis*)	Perimeter
		Switchgrass *(Panicum virgatum)*	Perimeter

Source: Adapted from NYDEC, 2001; New England Wetland Plants, Inc.

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Appendix B: Water Quality Flow (WQF) and Flow Diversion Guidance

Water Quality Flow Calculation

The water quality flow (WQF) is the peak flow rate associated with the water quality design storm. This section describes the recommended procedure for calculating the water quality flow (WQF) for the design of:

- Grass drainage channels (not water quality swales, which should be designed based on water quality volume - WQV)
- Pre-manufactured stormwater treatment devices (e.g., hydrodynamic separators, catch basin inserts, and media filters)
- Flow diversion structures for off-line stormwater treatment practices.

The WQF should be calculated using the WQV described in Chapter Seven. This WQV, converted to watershed inches, should be substituted for the runoff depth (Q) in the Natural Resources Conservation Service (formerly Soil Conservation Service), TR-55 Graphical Peak Discharge Method. The procedure is based on the approach described in Claytor and Schueler (1996).

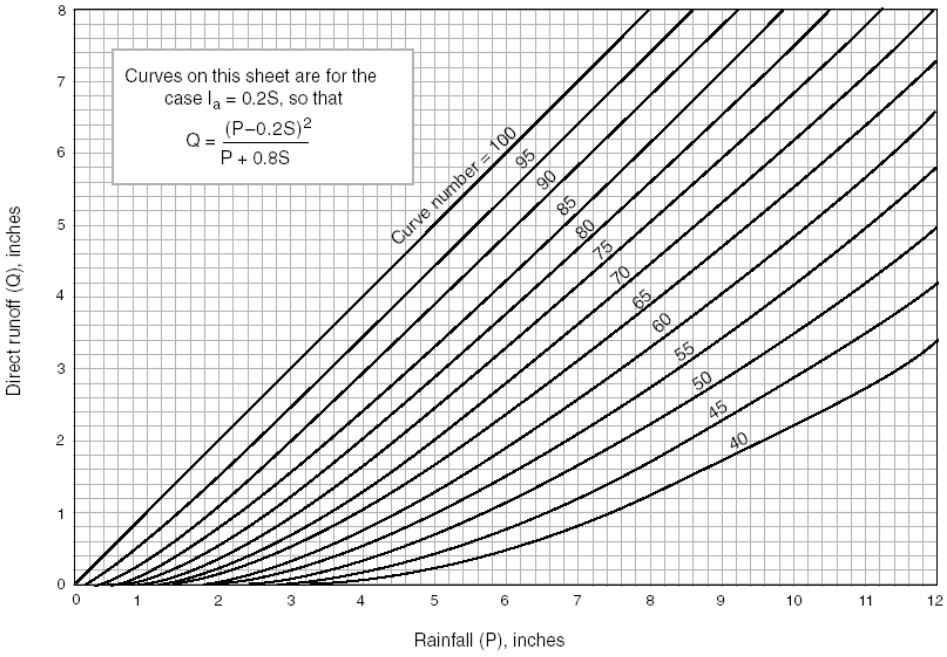
1. Compute the NRCS Runoff Curve Number (CN) using the following equation, or graphically using Figure 2-1 from TR-55 (USDA, 1986) (reproduced below):

$$CN = \frac{1000}{\left[10 + 5P + 10Q - 10\left(Q^2 + 1.25QP\right)^{1/2}\right]}$$

where: CN = Runoff Curve Number
P = design precipitation, inches (1" for water quality storm)
Q = runoff depth (in watershed inches)

$$= \frac{\left[WQV(acre-feet)\right] \times \left[12(inches/foot)\right]}{DrainageArea(acres)}$$

Figure 2-1 Solution of runoff equation.



2. Compute the time of concentration (t_c) based on the methods described in Chapter 3 of TR-55. A minimum value of 0.167 hours (10 minutes) should be used. For sheet flow, the flow path should not be longer than 300 feet.

3. Using the computed *CN*, t_c, and drainage area (*A*) in acres, compute the peak discharge for the water quality storm (i.e., the water quality flow [*WQF*]), based on the procedures described in Chapter 4 of TR-55.

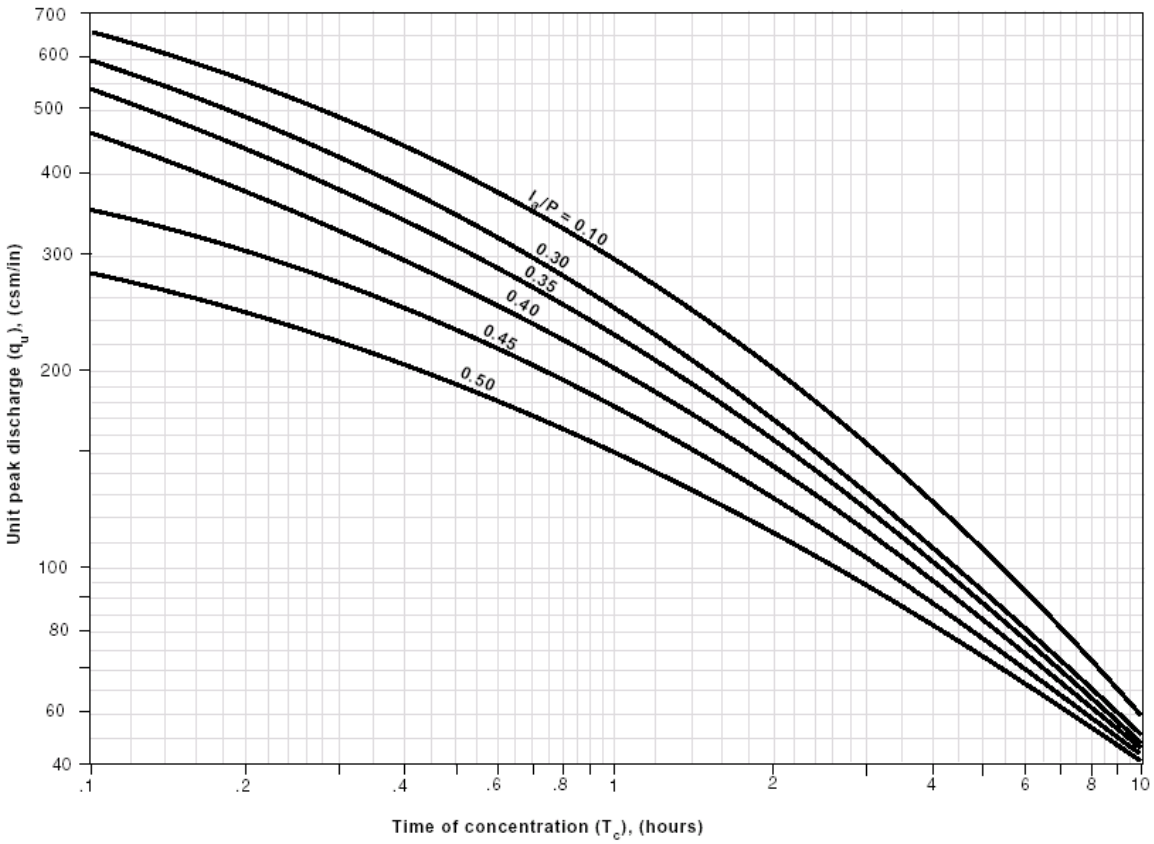
    - Read initial abstraction (I_a) from Table 4-1 in Chapter 4 of TR-55 (reproduced below); compute I_a/P

Table 4-1 I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

- Read the unit peak discharge (q_u) from Exhibit 4-III in Chapter 4 of TR-55 (reproduced below) for appropriate t_c

Exhibit 4-III Unit peal discharge (q_u) for NRCS (SCS) type III rainfall distribution



- Substituting the water quality volume (WQV), converted to watershed inches, for runoff depth (Q), compute the water quality flow (WQF) from the following equation:

$$WQF = (q_u)(A)(Q)$$

where:
WQF = water quality flow (cfs)
q_u = unit peak discharge (cfs/mi^2/inch)
A = drainage area (mi^2)
Q = runoff depth (in watershed inches)

$$= \frac{[WQV(acre-feet)]\times[12(inches/foot)]}{DrainageArea(acres)}$$

Other peak flow calculation methods may be used for determining the WQF, such as those recommended by manufacturers of proprietary treatment systems, provided that the WQF calculated by other methods is equal to or greater than the WQF calculated using the above NRCS Graphical Peak Discharge Method.

Flow Diversion Structures

Flow diversion structures, also called flow splitters, are designed to deliver flows up to the design water quality flow (WQF) or water quality volume (WQV) to off-line stormwater treatment practices. Flows in excess of the WQF or WQV are diverted around the treatment facility with minimal increase in head at the flow diversion structure to avoid surcharging the treatment facility under higher flow conditions. Flow diversion structures are typically manholes or vaults equipped with weirs, orifices, or pipes to bypass excess runoff. A number of design options exist. Figures B-1 through B-3 show common examples of flow diversion structures for use upstream of stormwater treatment practices. Other equivalent designs that achieve the result of diverting flows in excess of the WQF or WQV around the treatment facility, including bypasses or overflows located inside the facility, are also acceptable.

The following general procedures are recommended for design of flow diversion structures:

- Locate the top of the weir or overflow structure at the maximum water surface elevation associated with the WQF, or the water surface elevation in the treatment practice when the entire WQV is being held, whichever is higher.

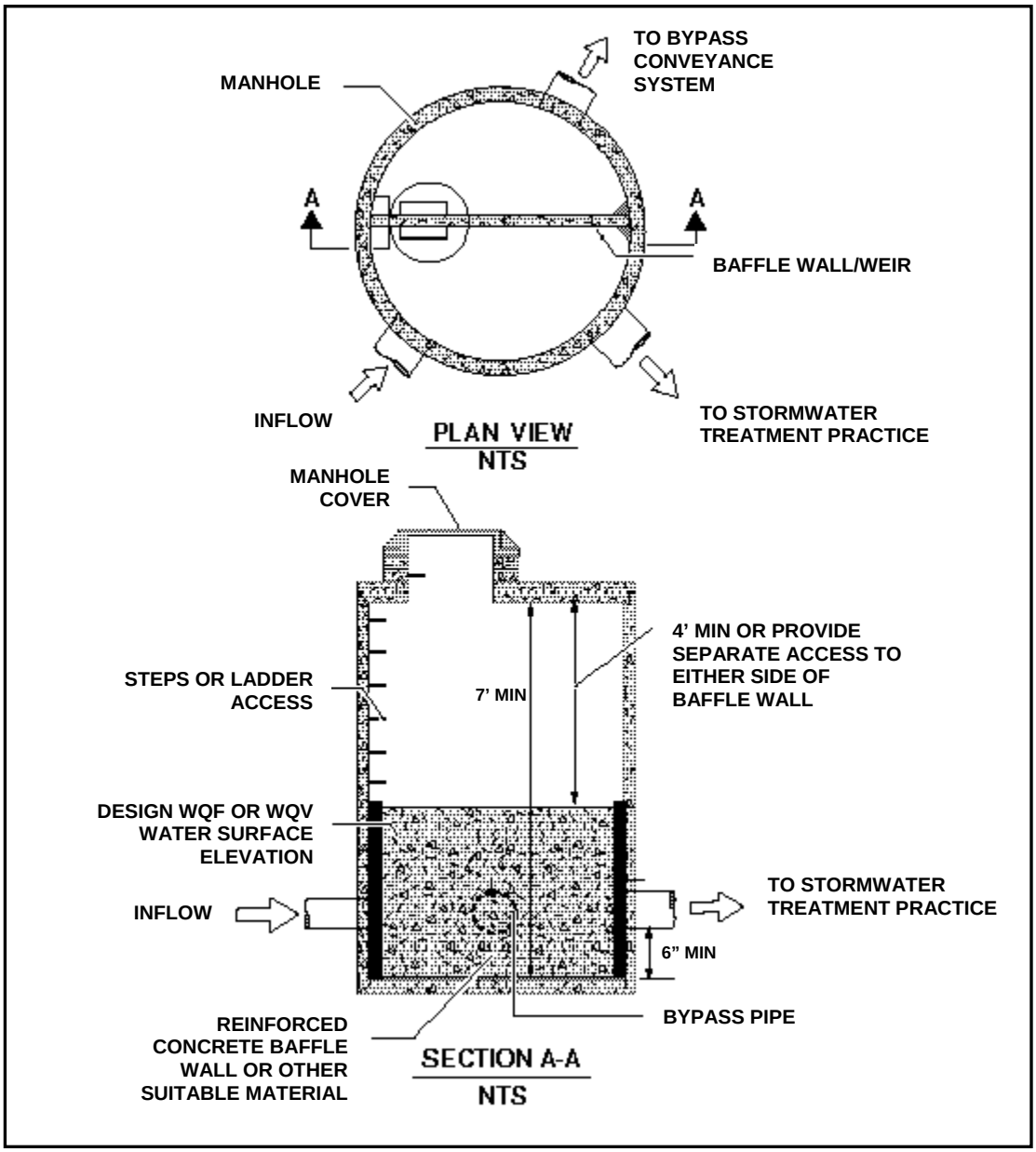
- Determine the diversion structure dimensions required to divert flows in excess of the WQF using standard equations for a rectangular sharp-crested weir, uniform flow in pipes or channels, or orifice depending on the type of diversion structure.

- Provide sufficient freeboard in the stormwater treatment practice and flow splitter to accommodate flow over the diversion structure.

- Limit the maximum head over the flow diversion structure to avoid surcharging the stormwater treatment practice under high flow conditions. Flow to the stormwater treatment practice at the 100-year water surface elevation should not increase the WQF by more than 10 percent.

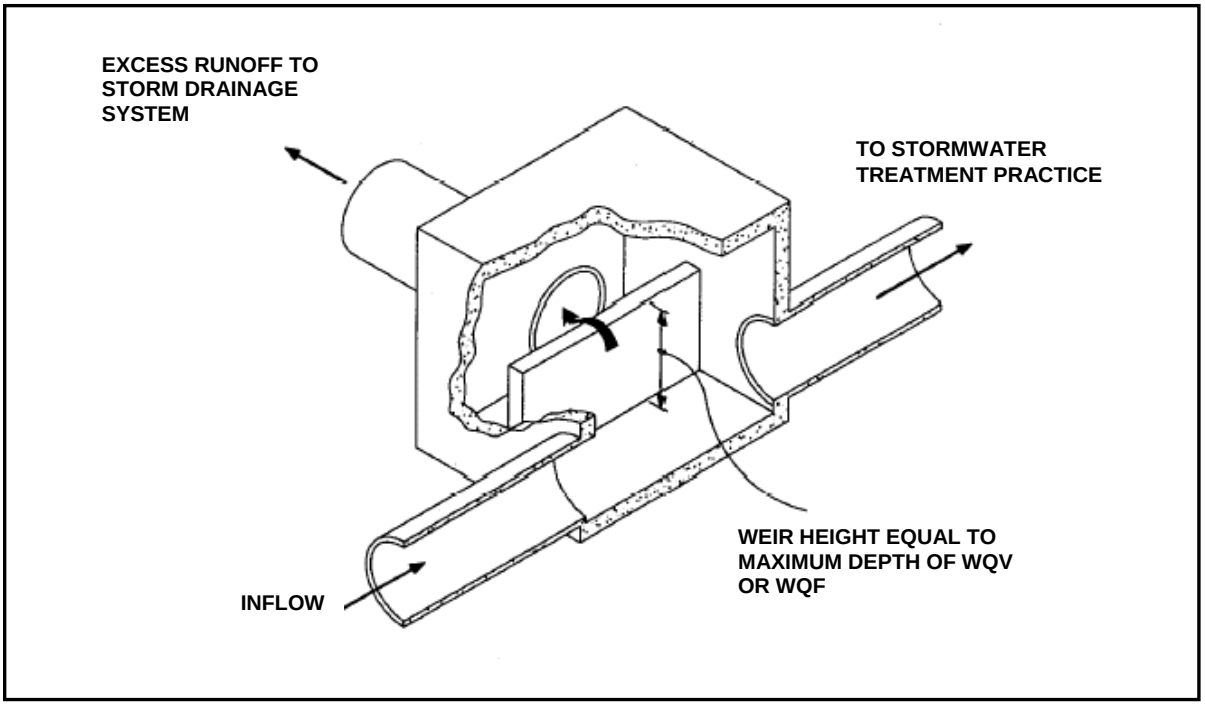
- Design diversion structures to withstand the effects of freezing, frost in foundations, erosion, and flotation due to high water conditions. These structures should be designed to minimize clogging potential and to allow for ease of inspection and maintenance.

Figure B-1. Flow Diversion Structure Design Option 1



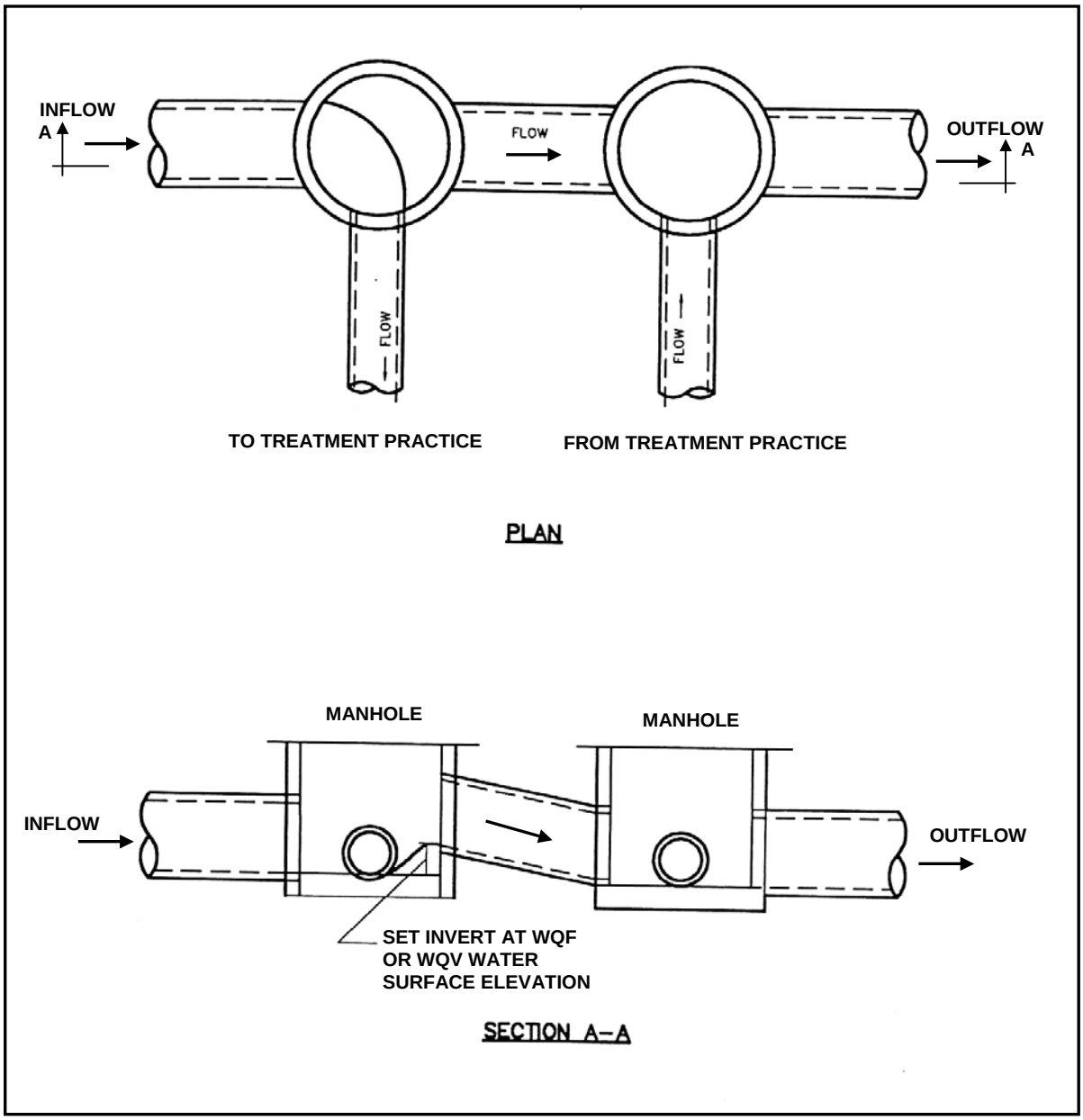
Source: Adapted from Washington, 2000.

Figure B-2. Flow Diversion Structure Design Option 2



Source: Adapted from City of Sacramento, 2000.

Figure B-3. Flow Diversion Structure Design Option 3



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U.S. Department of Agriculture, Natural Resources Conservation Service (formerly Soil Conservation Service), *Urban Hydrology for Small Watersheds, Technical Release No. 55*, Washington, D.C., June 1986.

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Appendix C: Model Ordinances

This Appendix contains model ordinances for:

- Illicit Discharge Detection and Elimination (Rhode Island DEM)
- Stormwater Operation and Maintenance (Rhode Island DEM)

Illicit Discharge Detection Model Ordinance

Section 1- Purpose

Increased and contaminated storm water runoff is a major cause of impairment of water quality and flow in lakes, ponds, streams, rivers, wetlands and groundwater; contamination of drinking water supplies; alteration or destruction of aquatic and wildlife habitat; and flooding. Regulation of illicit connections and discharges to the municipal storm drain system is necessary for the protection of the [city or town's] water bodies and groundwater, and to safeguard the public health, safety, welfare and the environment.

The objectives of this ordinance are:

1. to prevent (or reduce to the maximum extent practicable) pollutants entering [city or town's] municipally owned separate storm sewer system;

2. to prohibit illicit connections and unauthorized discharges to the MS4;
3. to require the removal of all such illicit connections and discharges;
4. to comply with state law and federal statutes and regulations relating to storm water discharges; and
5. to set forth the legal authority and procedures to carry out all inspection, monitoring and enforcement activities necessary to ensure compliance with this ordinance.

Section 2- Authority

This ordinance is promulgated pursuant to the Rhode Island Department of Environmental Management's ("DEM") *General Permit Rhode Island Pollutant Discharge Elimination System Storm Water Discharge from Small Municipal Separate Storm Sewer Systems and from Industrial Activity at Eligible Facilities Operated by Regulated Small MS4s* and in accordance with the Administrative Procedures Act, R.I.G.L. 42-35-1, *et seq.*

Section 3- Definitions

Allowable Non-Storm Water Discharges- Discharges not comprised of storm water are allowed under the MS4 General Permit but are limited to the following, provided these are not significant contributors of pollutants to the MS4: discharges which result from the washdown of vehicles at retail dealers selling new and used automobiles where no detergents are used and individual residential car washing; external building washdown where no detergents are used; the use of water to control dust; fire fighting activities; fire hydrant flushings; natural springs; uncontaminated groundwater; dechlorinated pool discharges; air conditioning condensate; lawn watering; potable water sources including waterline flushings; irrigation drainage; pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled materials have been removed) and where detergents are not used; discharges from foundation or footing drains where flows are not contaminated with process materials such as solvents, or contaminated by contact with soils where spills or leaks of toxic or hazardous materials have occurred; uncontaminated utility vault dewatering; dechlorinated water line

testing water; hydrostatic test water that does not contain any treatment chemicals and is not contaminated with process chemicals.

Authorized Enforcement Agency- Employees or designees of the director of the municipal agency designated to enforce this ordinance.

Best Management Practices (BMPs)- Schedules of activities, prohibitions of practices, general good house keeping practices, pollution prevention and educational practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants directly or indirectly to storm water, receiving waters, or storm water conveyance systems. BMPs also include treatment practices, operating procedures, and practices to control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw materials storage.

Clean Water Act (CWA)- The federal Water Pollution Control Act (33 U.S.C. § 1251 *et seq.*), and any subsequent amendments thereto.

Construction Activity- Activities subject to RIPDES Construction Permits. As of March 2003, RIPDES Storm Water Phase II permits are required for construction projects resulting in land disturbance of 1 acre or more. Such activities include but are not limited to clearing and grubbing, grading, excavating, and demolition.

Discharger - Any person who causes, allows, permits, or is otherwise responsible for a discharge, including, without limitation, any operator of a construction site or industrial facility.

Hazardous Material- Any material, including any substance, waste, or combination thereof, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause, or significantly contribute to, a substantial present or potential hazard to human health, safety, property, or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

Illicit Connection- An illicit connection is defined as either of the following: Any drain or conveyance, whether on the surface or subsurface, which allows an illegal discharge to enter the storm drain system including but not limited to any conveyances which allow any non-storm water discharge including sewage, process wastewater, and wash water to enter the storm drain system and any connections to the storm drain system from indoor drains and sinks, regardless of whether said drain or connection had been previously allowed, permitted, or approved by an authorized enforcement agency or, any drain or conveyance connected from a commercial or industrial land use to the storm drain system which has not been documented in plans, maps, or equivalent records and approved by an authorized enforcement agency.

Illicit Discharge- Any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to a RIPDES permit (other than the RIPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

Municipal Separate Storm Sewer System (MS4)- A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a city or town or the State district association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under Section 208 of the CWA that discharges to waters of the State;

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined in Rule 3 of the RIPDES Regulations.

Non-Storm Water Discharge- Any discharge that is not composed entirely of storm water.

Operator- The party or parties that either individually or taken together have the day-to-day operational control over the faculties activities and the ability to make modifications to such activities.

Owner- The party or parties that either individually or taken together has legal title to any premise.

Person- Any individual, association, organization, partnership, firm, corporation or other entity recognized by law and acting as either the owner or as the owner's agent.

Pollutants- Anything which causes or contributes to pollution. Pollutants may include, but are not limited to: paints, varnishes, and solvents; oil and other automotive fluids; non-hazardous liquid and solid wastes and yard wastes; refuse, rubbish, garbage, litter, or other discarded or abandoned objects, ordinances, and accumulations, so that same may cause or contribute to pollution; floatables; pesticides, herbicides, and fertilizers; hazardous substances and wastes; sewage, fecal coliform and pathogens; dissolved and particulate metals; animal wastes; wastes and residues that result from constructing a building or structure; and noxious or offensive matter of any kind.

Storm Water- Any surface flow, runoff, and drainage consisting entirely of water from any form of natural precipitation, and resulting from such precipitation.

Unauthorized Discharge- A discharge of storm water not authorized by a RIPDES permit, or an allowable storm water discharge found to be a significant contributor of pollutants to the MS4.

Watercourse- A natural or man-made surface drainage channel or body of water (including a lake or pond) through which a water flow occurs, either continuously or intermittently.

Waters of the State- Surface and ground waters within the boundaries of the State of Rhode Island and subject to its jurisdiction.

Section 4- Discharge Prohibitions

Prohibition of Unauthorized Discharges

No person shall discharge or caused to be discharged into the municipal separate storm sewer system or watercourses any pollutant or non-storm water discharge unless such a non-storm water discharge is outlined in Part I.B.3 of the MS4 General Permit. The allowable non-storm water discharges (described below) are permitted if deemed not to be a significant contributor of a pollutants to the municipal separate storm sewer system.

Allowable non-storm water discharges:

1. discharges which result from the washdown of vehicles at retail dealers selling new and used automobiles where no detergents are used and individual residential car washing;
2. external building washdown where no detergents are used;
3. the use of water to control dust;
4. fire fighting activities;
5. fire hydrant flushings;
6. natural springs;
7. uncontaminated groundwater; dechlorinated pool discharges;
8. air conditioning condensate;
9. lawn watering; potable water sources including waterline flushings;
10. irrigation drainage;
11. pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled materials have been removed) and where detergents are not used;
12. discharges from foundation or footing drains where flows are not contaminated with process materials such as solvents, or contaminated by contact with soils where spills or leaks of toxic or hazardous materials have occurred;
13. uncontaminated utility vault dewatering; dechlorinated water line testing water;
14. hydrostatic test water that does not contain any treatment chemicals and is not contaminated with process chemicals.

Prohibition of Illicit Connections
The construction, use, maintenance or continued existence of illicit connections to the municipal separate storm sewer system is prohibited. This prohibition expressly includes, without limitation, illicit connections made in the past, regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection.

A person is considered to be in violation of this ordinance if the person connects a line conveying sewage to the MS4, or allows such a connection to continue and must provide corrective action.

Section 5- Suspension of MS4 Access

Suspension due to Illicit Discharges in Emergency Situations.
The _____ [authorized enforcement agency] may, without prior notice, suspend MS4 discharge access to a person when such suspension is necessary to stop an actual or threatened non-storm water discharge which presents or may present imminent and substantial danger to the environment, or to the health or welfare of persons, or to the MS4 or Waters of the State. If the violator fails to comply with a suspension order issued in an emergency, the authorized enforcement agency may take such steps as deemed necessary to prevent or minimize damage to the MS4 or Waters of the State, or to minimize danger to persons.

Suspension due to the Detection of Illicit Discharge.
Any person discharging to the MS4 in violation of this ordinance may have their MS4 access terminated if such termination would abate or reduce an illicit discharge. The authorized enforcement agency will notify a violator of the proposed termination of its MS4 access. The violator may petition the authorized enforcement agency for reconsideration and a hearing. A person commits an offense if the person reinstates MS4 access to premises terminated pursuant to this Section, without the prior approval of the authorized enforcement agency.

Entry to Perform Duties Under this Ordinance.
To the extent permitted by State law, or if authorized by the owner or other party in control of the property, the authorized enforcement agency, its agents, officers, and employees may enter upon privately owned property for the purpose of performing their duties under this ordinance and may make or cause to be made such examinations, surveys or sampling as the authorized enforcement agency deems reasonably necessary.

Section 6- Industrial and Construction Activity Discharge
Any person subject to an industrial or construction activity RIPDES storm water discharge permit shall comply with all provisions of such permit. Proof of compliance with said permit may be required in a form acceptable to the authorized enforcement agency prior to the allowing of discharges to the MS4.

Section 7- Inspections and Monitoring

The authorized enforcement agency shall be permitted, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter the dischargers premise(s) where a regulated activity is conducted, or where records must be kept as required under the conditions of this permit;
2. Have access to and copy, at reasonable times, any records that must be kept as required under the conditions of the permit;
3. Inspect at reasonable times any equipment, practices, or operations regulated or required under this permit; and

4. Sample or monitor any substances or parameters at any location, at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the CWA or R.I. law.

Section 8- Requirement to Prevent, Control and Reduce Storm Water Pollutants

In an attempt to prevent, control, and reduce storm water pollutants any person engaged in activities or operations, or owning facilities or property which will or may result in pollutants entering storm water, the storm sewer system or waters of the State shall implement Best Management Practices to the extent they are technologically achievable to prevent and reduce such pollutants. The owner or operator of a commercial or industrial establishment shall provide reasonable protection from accidental discharge of prohibited materials or other wastes into the municipal storm drain system or watercourses. Facilities to prevent accidental discharge of prohibited materials or other wastes shall be provided and maintained at the owner or operator's expense.

Section 9- Watercourse Protection

Every person owning property through which a watercourse passes, or such person's lessee, shall keep and maintain that part of the watercourse within the property reasonably free of trash, debris, excessive vegetation, and other obstacles that would pollute, contaminate, or significantly retard the flow of water through the watercourse. In addition, the owner or lessee shall maintain existing privately owned structures within or adjacent to a watercourse, so that such structures will not become a hazard to the use, function, or physical integrity of the watercourse. The owner or lessee shall not remove healthy bank vegetation beyond that actually necessary for maintenance, nor remove said vegetation in such a manner as to increase the vulnerability of the watercourse to erosion. The property owner or lessee shall be responsible for maintaining and stabilizing that portion of the watercourse that is within their property lines in order to protect against erosion and degradation of the watercourse originating or contributed from their property. Nothing in this section shall preclude any owner/lessee from compliance with relevant provisions of the Rhode Island Freshwater Wetlands Act, R.I.G.L. 2-1-18, *et seq.*or other applicable laws or regulations.

Section 10- Notification of Spills

Notwithstanding other requirements of law, as soon as any person responsible for a facility or operation, or responsible for emergency response for a facility or operation has information of any known or suspected release of materials which are resulting or may result in unauthorized discharges or pollutants discharging into storm water, the storm drain system, or waters of the State from said facility, said person shall take all necessary steps to ensure the discovery, containment, and cleanup of such release. In the event of such a release of a hazardous material said person shall immediately notify emergency response officials of the occurrence via emergency dispatch services (911). In the event of a release of non-hazardous materials, said person shall notify the authorized enforcement agency no later than the next business day. Notifications in person or by phone shall be confirmed by written notice addressed and mailed to the authorized enforcement agency within _____business days of the phone notice. If the discharge of prohibited materials emanates from a commercial or industrial establishment, the owner or operator of such establishment shall also retain an on-site written record of the

discharge and the actions taken to prevent its recurrence. Such records shall be retained for at least three years. Nothing in this section shall preclude any owner/lessee from compliance with relevant provisions of the Rhode Island Clean Water Act, R.I.G.L. 46-12-1, et seq.or other applicable laws or regulations.

Section 11-Enforcement

A. Notice of Violation

Whenever the authorized enforcement agency finds that any person has violated a prohibition or failed to meet a requirement of this Ordinance, the authorized enforcement agency may order compliance by written notice of violation to the responsible person. Such notice may require without limitation:

1. The performance of monitoring, analyses, and reporting;
2. The elimination of illicit connections or discharges;
3. That violating discharges, practices, or operations shall cease and desist;
4. The abatement or remediation of storm water pollution or contamination hazards and the restoration of any affected property; and
5. Payment of a fine to cover administrative and remediation costs; and
6. The implementation of source control or treatment BMPs.

If abatement of a violation and/or restoration of affected property is required, the notice shall set forth a deadline within which such remediation or restoration must be completed. Said notice shall further advise that, should the violator fail to remediate or restore within the established deadline, the work will be done by a designated governmental agency or a contractor and the expense thereof shall be charged to the violator.

Section 12- Appeal of Notice of Violation

Any person receiving a Notice of Violation may appeal the determination of the authorized enforcement agency. The notice of appeal must be received within ____ days from the date of the receipt of the Notice of Violation. The notice of appeal shall be in writing and contain a detailed basis upon which the appeal was taken. The procedure for said appeal shall be in conformity with the Administrative Procedures Act, R.I.G.L. 42-35-1, et seq.

Section 13- Settlements of Appeal of Notice of Violation

In lieu of enforcement proceedings, penalties, and remedies authorized by this Ordinance, the authorized enforcement agency may enter into a negotiated settlement to resolve the appeal of the Notice of Violation. Such settlement may impose upon a violator alternative compensatory actions, such as storm drain stenciling, attendance at compliance workshops, creek cleanup, etc.

Section 14-Enforcement Measures After Appeal

If no timely appeal of a Notice of Violation has been taken and the violation has not been corrected pursuant to the requirements set forth in the Notice of Violation, or, in the event of

an appeal, within ___days of the decision of the municipal authority upholding the decision of the authorized enforcement agency, then representatives of the authorized enforcement agency shall undertake all necessary actions, including requesting injunctive relief through the Superior Court, to enter upon the subject private property and take any and all measures necessary to abate the violation and/or restore the property

Section 15- Administrative Orders

The authorized enforcement agency is authorized to issue the following administrative orders at any time they deem such action appropriate to secure timely and effective compliance with this Ordinance or a discharge permit or order issued pursuant to this Ordinance, whether or not any previous notifications of violation have been provided to the user.

A. *Cease and Desist Order:* The authorized enforcement agency may issue an order to cease and desist a violation or an action or inaction which threatens a violation and to direct the user to comply forthwith or to take such appropriate remedial or preventive action as may be needed to properly address the violation or threatened violation, including halting operations and terminating the discharge.

B. *Compliance Order:* The authorized enforcement agency may issue an order requiring a user to provide within a specified period of time, such treatment, pretreatment or discharge control facilities or related appurtenances as are necessary to correct a violation or to prevent a threatened violation. A compliance order may also direct that a user provide improved operation and maintenance of existing discharge facilities, conduct additional self-monitoring or submit appropriate reports or management plans.

C. *Show Cause Order:* The authorized enforcement agency may issue an order to show cause why a proposed enforcement action should not be taken. Notice shall be served on the user specifying the time and place for a meeting, the proposed enforcement action and the reasons for such action, and a request that the user show cause why the proposed enforcement action should not be taken. Whether or not a duly notified user appears as noticed, additional enforcement action may be initiated.

D. *Consent Order:* The authorized enforcement agency may enter into consent orders, assurances of voluntary compliance, or other similar documents establishing an agreement with a user. Such orders shall include specific actions to be taken by the user and specific time frames to correct a violation or to remove the threat of a violation.

Section 16- Cost of Abatement of the Violation

Within __ days after abatement of the violation, by or under the direction of the authorized enforcement agency, the owner of the property will be notified by the enforcement agency or municipality of the cost of abatement, including administrative costs. If the amount due is not paid within a timely manner as determined by the enforcement agency or municipality, the charges shall become a special assessment against the property and shall constitute a lien on the property for the amount of the assessment. Any person violating any of the provisions of this section shall become liable to the city by reason of such violation. The liability shall be paid in

not more than 12 equal payments. Interest at the rate of 12 percent per annum shall be assessed on the balance beginning on the __ st day following discovery of the violation.

Section 17- Injunctive Relief

It shall be unlawful for any person to violate any provision or fail to comply with any of the requirements of this Ordinance. If a person has violated or continues to violate the provisions of this ordinance, the authorized enforcement agency may petition for a temporary, preliminary or permanent injunction restraining the person from activities which would create further violations or compelling the person to perform abatement or remediation of the violation.

Section 18-Violations Deemed a Public Nuisance

In addition to the enforcement processes and penalties provided, any condition caused or permitted to exist in violation of any of the provisions of this Ordinance is a threat to public health, safety, and welfare, and is declared and deemed a nuisance, and may be summarily abated or restored at the violator's expense, and/or a civil action to abate, enjoin, or otherwise compel the cessation of such nuisance may be taken.

Section 19- Criminal Prosecution

Any person that has violated or continues to violate this Ordinance shall be liable to criminal prosecution to the fullest extent of the law, and shall be subject to a criminal penalty of _____ dollars per violation per day and/or imprisonment for a period of time not to exceed ____ days.
The authorized enforcement agency may recover all attorney's fees, court costs and other expenses associated with enforcement of this Ordinance, including sampling and monitoring expenses.

Section 20-Remedies Not Exclusive

The remedies listed in this ordinance are not exclusive of any other remedies available under any applicable federal, state or local law and it is within the discretion of the authorized enforcement agency to seek cumulative remedies.

Section 21- Adoption of Ordinance

This ordinance shall be in full force and effect __ days after its final passage and adoption. All prior ordinances and parts of ordinances in conflict with this ordinance are hereby repealed.
PASSED AND ADOPTED this ____ day of _____, 20__, by the following vote:

Model Stormwater Control Ordinance

Section 1

1.1 Purpose

Unmitigated stormwater from areas altered by development may pose public health and safety threats. Potential contaminants in stormwater runoff may include suspended solids, nitrogen, phosphorus, hydrocarbons, heavy metals, pathogenic organisms (bacteria and viruses), and road salts. Stormwater runoff may impact any water resource—surface water, groundwater and wetlands—and is often cited as the most significant contributor of nonpoint source water pollution.

Best management practices for stormwater management help to prevent adverse impact. However, practices must be designed, installed and maintained properly to ensure their effective function. Practices that do not function properly may degrade water quality as well as present nuisance and safety hazards.

This ordinance establishes the administrative mechanisms necessary for *[name of municipality]* to ensure proper stormwater management. The ordinance is written to work in conjunction with current state regulations.

1.2 Applicability

This ordinance shall apply to all development occurring within *[name of municipality]*. No person shall engage in land development activities without receiving approval from *[name of governing body]*, unless specifically exempted by Section 1.3 of this ordinance.

1.3 Exemptions

The following activities do not require written approval pursuant to this ordinance:

(A) Agricultural land management activities carried out in accordance with a conservation management plan that has been approved by the Natural Resources Conservation Service.

(B) Additions or modifications to existing single-family residential structures.

(C) Grading, as a maintenance measure or for landscaping, on contiguous areas of developed land, parcels and lots, which in aggregate do not exceed five thousand (5,000) square feet.

1.4 Variance

The _____ (municipal board or official) reviewing an application under this ordinance may:

(A) Vary requirements of this ordinance when strict implementation of the requirements of this ordinance create an unnecessary hardship or are not feasible.

(B) Allow use of an innovative management practice where strict adherence to existing criteria would be costly or of negligible environmental benefit.

1.5 Compatibility with Other Enforceable Policies

This ordinance shall not obviate or supersede any other federal, state or local regulations or statutes. The provisions of this ordinance shall be held to be minimum requirements for the promotion of public health, safety and general welfare. If a provision of this ordinance imposes a standard different from any related regulation or statute, the provision that imposes the more protective standard shall be observed.

1.6 Severability

If the provisions of any article, section, subsection, paragraph, subdivision or clause of this ordinance shall be judged invalid by court of competent jurisdiction, such order of judgment shall not affect or invalidate the remainder of any article, section, subsection, paragraph, subdivision or clause of this ordinance.

Section 2--Definitions

The following definitions apply to this ordinance.

AGRICULTURAL DEVELOPMENT: means land uses normally associated with the production of food, fiber and livestock for sale. For purposes of this ordinance, such uses shall not include the development of land for the processing or sale of food and the manufacturing of agriculturally related products.

BEST MANAGEMENT PRACTICE (BMP): means a method for pollution management, which is deemed to provide the best available treatment or control of a pollution source such as stormwater.

DETENTION BASIN: means an embankment and associated space for impoundment of water or, alternatively, the space for impoundment partially or entirely created by excavation rather than by embankment, in either case designed to temporarily retain stormwater runoff.

FLOOD HAZARD AREAS: means the floodway and flood fringe areas determined or delineated by the Department of Environmental Management.

FLOOD PLAIN: means the flood hazard areas of streams delineated the Department of Environmental Management and areas inundated by the 100-year flood in areas not delineated by the Department of Environmental Management.

FLOODWAY: means the channel of a natural stream and portions of the flood hazard areas adjoining the channel, which are reasonably required to carry and discharge the flood water or flood flow of any natural stream.

INFILTRATION BASIN: means a detention facility, which is not an injection well, that is designed to gradually filter and pass retained water to the subsurface.

NONPOINT SOURCE POLLUTION: means pollution from any source that is not discernible, confined and discrete. Potential sources of nonpoint pollution include, but are not limited to, stormwater runoff, agriculture, silviculture, mining, construction, septic systems and urban development.

RECHARGE: means the replenishment of underground water reserves.

STORMWATER RUNOFF: means flow on the surface of the ground, resulting from precipitation.

WET BASIN: means a detention basin designed to retain some water on a permanent basis.

WETLANDS: means an area, as defined by the Rhode Island General Laws and as determined by the Department of Environmental Management or the Coastal Resources Management Council, which is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support--and under normal circumstances does support--a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation.

Section 3—Submissions and Approvals

In accordance with Section 1.2 of this ordinance, all persons must obtain approval from *(name of municipal review board)* prior to engaging in any land development activities, unless exempted by Section 1.3 of this ordinance. To obtain approval applicants must demonstrate compliance with all policy, standards and requirements of this ordinance to the satisfaction of the *(name of municipal review board).* Applicants may demonstrate compliance via submission of materials and documentation in accordance with this section.

3.1 Stormwater Management Plan

All applicants shall provide a stormwater management plan as part of the submission for approval. Stormwater management plans shall incorporate the following.

(A) A discussion of protection of environmental resource functions and values in accordance with Section of this ordinance.

(B) A discussion of best management practices employed, in accordance with this ordinance, both during construction and post construction.

(C) A discussion of best management practice maintenance to be used, in accordance with this ordinance, both during construction and post construction.

3.2 Site Plan

All applicants shall provide a site plan as part of the submission for approval. Site plans shall incorporate the following.

(A) A map of existing site conditions in accordance with Section of this ordinance.

(B) Maps of the site showing all phases of construction of the proposed project in accordance with Section of this ordinance.

(C) Site planning calculations in accordance with Section of this ordinance.

(D) A narrative description of the proposed project in accordance with Section of this ordinance.

3.3 Maintenance Agreement

All applicants shall provide a maintenance agreement as part of the submission for approval in accordance with Section of this ordinance.

3.4 Performance Surety

All applicants shall provide performance surety as part of the submission for approval. The performance surety shall incorporate the following.

(A) A letter of credit in accordance with Section of this ordinance.

(B) Evidence of posting in accordance with Section of this ordinance.

3.5 Processing of Submittals

Procedures for processing of submittals shall be as follows.

(A) Submittals for approval shall be provided to *[name of municipal governing board]* for review, processing and approval. *[Number of copies to be provided by applicant]* copies of the submittal shall be provided.

(B) All applicants shall provide an application fee as part of the submittal. Application fees shall be charged in accordance with Section10 of this ordinance.

(C) A review of the submittal shall be conducted by *[name of municipal governing board]* within *[number of days required for review]* days from the date of receipt. Written comments shall be provided to the applicant regarding the completeness of the submittal and requesting further information as necessary.

(D) If *[name of municipal governing board]* determines the submittal to be in compliance with the requirements of this ordinance, a permit may be issued. If the *[name of municipal governing board]* determines the submittal does not fully conform to the requirements of this ordinance a written denial shall be issued with an explanation for the denial.

(E) Any applicant who believes that a submission for approval has been denied without sufficient cause and that the submittal fully conforms with this ordinance may petition *[name of municipal governing board]* in writing. If the applicant is again denied, the denial may be appealed to *[name of municipal appeals board]*, whose decision shall be final.

Section 4--Protection of functions and values

4.1 Wildlife And Wildlife Habitat Values

Stormwater management plans shall address protection of areas that provide wildlife habitat benefits.

4.2 Recreation and Cultural Values

Stormwater management plans shall address protection of areas that provide recreational, cultural or aesthetic values.

4.3 Flood Protection

Stormwater management plans shall demonstrate that a proposed project provides for protection of life and property from flooding and flood flows. Water quantities must be controlled in accordance with the *Rhode Island Stormwater Design and Installation Standards Manual*, as amended, or a municipally approved regional stormwater management plan for the watershed in which the development site is located. Stormwater management plans shall demonstrate incorporation of the following standards into the proposed project:

(A) Control and maintenance of post development peak discharge rates from the 2-year and 25-year storm events and predevelopment levels.

(B) Downstream analysis of the 100-year storm event and control of the peak discharge rate for the 100-year storm to mitigate significant downstream impacts.

(C) Discharge from any stormwater facility must be conveyed through properly constructed watercourses to provide for nonerosive flows during all storm events. The proposed stormwater conveyance system consisting of open channels, pipes, and other conveyance devices shall at a minimum accommodate the runoff from a 10-year storm event. The stormwater conveyance system must provide for nonerosive flows to receiving waters.

4.4 Surface Water And Groundwater

Stormwater management plans shall demonstrate that during develop and post development, all receiving waters will be recharged in a manner closely resembling predevelopment conditions and that the developed site will retain hydrological conditions that closely resemble of those prior to disturbance.

Section 5—Technical Standards

All applicants are required to develop and submit a stormwater management plan. All stormwater management plans must address stormwater management on a site-by-site basis and all requirements of this ordinance. All stormwater management practices shall be consistent with the *Rhode Island Stormwater Design and Installation Standards Manual* and the *Rhode Island Soil Erosion and Sediment Control Handbook*, as amended. The following general standards and policies are also requirements of the state. However, a state permit, assent, or other approval does not necessarily assure similar municipal approval. In situations where the state determines that a project is below regulatory threshold or outside state jurisdiction, *[name of municipality]* will continue to require that the following policies and standards be upheld.

All development shall incorporate appropriate and practical stormwater management. Stormwater management shall be described by applicants in a stormwater management plan and submitted in accordance with Section # of this ordinance. Stormwater management plans shall be prepared in accordance with Appendix A of this ordinance and demonstrate the following to maximum extent practicable.

5.1 Soil Erosion And Sediment Control

Stormwater management plans shall demonstrate soil erosion and sediment control in accordance with the *Rhode Island Soil Erosion and Sediment Control Handbook*, as amended. Soil erosion and sediment control must incorporate the following:

(A) Fit development to the terrain.

(B) Divide the site into drainage areas to determine how runoff will travel over the site.

(C) Cluster buildings together to the extent allowable by municipal ordinances and regulations.

(D) Minimize impervious areas.

(E) Minimize disturbance of the natural drainage system.

(F) Keep land disturbance to a minimum.

(G) Stabilize disturbed areas.

(H) Keep runoff velocities low.

(I) Minimize the grades of slopes.

(J) Protect disturbed areas from stormwater runoff.

(K) Install perimeter sediment control practices.

(L) Prepare a thorough maintenance and inspection plan.

(M) Assign responsibility for a maintenance program.

(N) Coordinate with other development in the watershed.

5.2 Performance Standards

(A) Stormwater management plans shall incorporate best management practices for water quality control, which in combination are demonstrated to reduce the average annual total suspended solids in post development runoff by eighty percent (80%). Development in drinking water supply watersheds may be held to higher standards. To meet standards the following must be incorporated:

(B) The water quality design volume shall be defined as one inch (1") of runoff over all impervious surfaces or 0.4 inches of runoff over pervious areas. For purposes of computing runoff, all lands in the site shall be assumed, prior to development, to be in good hydrologic condition (if the lands are pastures, lawns or parks), with good cover (if the lands are woods), or with conservation treatment (if the land is cultivated), regardless of conditions existing at the times of computation. For lands to be considered cultivated, it shall have been used for such purposes uninterruptedly for a period of at least 10 years prior to the time of computation. If such uninterrupted use has not occurred or cannot be satisfactorily demonstrated, woods or brush shall be assumed to be the predeveloped land condition. All significant surface storage including open waters, ponding factors and hedgerows shall be accounted for in computing predevelopment runoff.

(C) Wet ponds must have a permanent pool volume equal to the water quality volume as described in item A.

(D) Extended detention dry ponds must detain the water quality volume over a 36-hour period (brim drawdown time).

(E) Infiltration methods must be designed to retain and exfiltrate the water quality volume over a maximum 72-hour period.

(F) All runoff up to the water quality design storm shall be controlled by one or more of the stormwater management best management practices as described in the *Rhode Island Stormwater Design and Installation Standards Manual*, as amended.

(G) Alternative land use, site design, source controls and structural controls may be used when they can be shown to provide equal or greater water quality protection, have acceptable maintenance requirements, and will be monitored to demonstrate their effectiveness on site.

5.3 Disallowed Stormwater Best Management Practices

(A) The following stormwater best management practices shall not be allowed in *[name of municipality]*, regardless of any other federal, state, regional or local policy or regulation. (list of disallowed best management practices)

(B) The placement of detention basins and other stormwater structures within a floodplain shall be avoided. If there is no alternative, the applicant must show what effects, if any, the tailwaters created by the floodplain will have on the outflow and effective storage capacity of the detention facility.

5.4 Safety

Safety measures are to be incorporated in the design of all stormwater and infiltration control projects. These may include but are not limited to fencing, warning signs/stadia rod indicating depth at the deepest point, outlet structures designed to limit public access, and aquatic benches in basins containing permanent or standing water levels.

5.5 Facilitation of Maintenance

Stormwater management facilities must be designed to operate with minimal maintenance. Facilities that require maintenance shall be designed to minimize the need for regular maintenance, facilitate required maintenance, and ensure accessibility of components that require maintenance. At a minimum, all stormwater management plans must incorporate best management practices with appropriate maintenance design in accordance with the *Rhode Island Stormwater Design and Installation Standards Manual*, as amended; or the *Rhode Island Soil Erosion and Sediment Control Handbook*, as amended. In addition, the following maintenance design standards and policies must be incorporated into management practice design and stormwater management plans.

(A) Strong, durable and noncorroding materials, components, and fasteners shall be incorporated in facility design and demonstrated in stormwater management plans. These include, but are not limited to, the following:

1. Lightweight noncorroding metals such as aluminum for trash racks, orifice plates, anti-seep collars, and access hatches.

2. Hardy, disease resistant grasses for bottoms and side slopes (as prescribed by Soil Erosion and Sediment Control Standards administered by the local Soil Conservation District).

3. Reinforced concrete for outlet structures and inlet headwalls; PVC piping for culverts, and riprap and gabions for channel and outlet linings.

(B) Stormwater management facility outlets shall be designed to function normally without manual, electric or mechanical controls.

5.6 Nuisance Control

All stormwater management plans and best management practices shall incorporate nuisance control as appropriate. The following are the required policies and minimum standards:

(A) To control weeds, disease and pests, a regularly scheduled program of mowing and trimming of bottoms, side-slopes and embankments shall be specified and conducted.

(B) Stormwater management facilities shall be designed to minimize propagation of insects, particularly mosquitoes.

5.7 Landscaping

Stormwater management facilities shall be designed in a harmonious and attractive manner that visually compliments the natural environment of the development site as well as the post developed condition.

(A) Use of landscaping as a method of reducing runoff and preventing pollutant inputs.

(B) Application of a minimal disturbance and minimal maintenance policy for landscaping. Where practical, clearing or site grading should only occur on land required for the structure and its associated utilities, drives, walks, and active recreational facilities. Following construction, unbuilt disturbed areas shall be revegetated with low- and no-maintenance, indigenous species.

(C) Where land disturbance is necessary and existing vegetation is removed, alternative landscaping, which encourages ground coverings, shade trees and shrubbery should be used. Landscaping should incorporate native vegetation to the maximum extent practicable. Use of lawns should be avoided where conditions indicate potential problems with turf establishment and maintenance.

(D) Appropriate fertilizer selection and application for vegetation reestablishment and landscaping.

Section 6—Maintenance Requirements for Best Management Practices

6.1 Routine Maintenance and Repair Procedures

(A) Preventative maintenance procedures are required to maintain the intended operation and safe condition of the stormwater management facility by greatly reducing the occurrence of problems and malfunctions. To be effective, preventative maintenance shall be performed on a regular basis and include such routine procedures as training of staff, periodic inspections, grass cutting (at least twice a year) and fertilizing, upkeep of moving parts, elimination of mosquito breeding habitats, and pond maintenance. Disposal of sediment and debris must occur on a regular basis (unless otherwise specified within an approved plan), at suitable disposal sites or recycling sites and comply with applicable local, state and federal regulations.

(B) Corrective maintenance procedures are required to correct a problem or malfunction at a stormwater management facility and to restore the facility's intended operation and safe condition. Based upon the severity of the problem, corrective maintenance must be performed on an as-needed or emergency basis and include such procedures as structural repairs, removal of debris, sediment and trash removal which threaten discharge capacity, erosion repair, snow and ice removal, fence repair, mosquito extermination, and restoration of vegetated and nonvegetated linings.

(C) In the event that the stormwater management facility becomes a danger to public safety or public health, or in need of maintenance, the City/Town of _____ shall so notify the responsible person in writing by certified mail. Upon receipt of that notice, the responsible person shall have fourteen (14) days to effect maintenance and repair of the facility in a manner that is approved by the municipality. If the responsible person fails or refuses to perform such maintenance and repair, the municipality may immediately proceed to do so and shall bill the cost thereof to the responsible person.

6.2 General Maintenance Standards for Stormwater Best Management Practices.

Maintenance design and maintenance procedures for all stormwater best management practices shall be in accordance *Rhode Island Stormwater Design and Installation Standards Manual*, as amended; or the *Rhode Island Soil Erosion and Sediment Control Handbook*, as amended. Stormwater management plans shall demonstrate appropriate maintenance design and procedures for each proposed best management practice. The following policies and standards for maintenance must be incorporated into stormwater management plans, as applicable.

(A) A maintenance schedule for each type of BMP must be included in the application package and on the final site plans. These schedules shall list the frequency and type of maintenance operations necessary along with the legally

responsible party's name, address, and telephone number. If the stormwater drainage system is to be deeded to the local municipality the applicant must obtain a letter from the municipality acknowledging maintenance responsibility and intent of ownership.

(B) An area must be set aside within the development site for the purpose of sediment disposal (where applicable). The disposal area shall be large enough to handle the volume of two clean-out cycles. The site may also serve as open space and recreation areas.

(C) Proper erosion and sediment control practices must be implemented during all phases of construction and until the site is satisfactorily stabilized. These plans must be printed on the final site plans submitted for approval. All control practices shall be in accordance with the most recent edition of the *Rhode Island Soil Erosion and Sediment Control Handbook*.

(D) Grasses selected for specific site conditions must be planted around and within basins immediately following construction to stabilize the slopes and prevent erosion. Trees and shrubs shall not be planted on any impounding embankments, to prevent potential subsurface disturbance and possible failure of the structure.

(E) Side-slopes, embankments, and the upper stage of basins shall be mowed at least once per growing season, to prevent unwanted woody growth. Mowing may be more frequent in residential areas if a more groomed appearance is desired, however if a stormwater facility is managed for wildlife habitat mowing shall be conducted after mid-August to prevent mortality to ground nesting birds and animals.

(F) All trash and litter and other debris shall be removed from any stormwater facility including inlet and outlet structures. Maintenance of this type improves the physical appearance of the facility and prevents blockage of inlet/outlet structures, thereby averting failure of the structure. This must be accomplished at least twice per year, preferably spring and fall.

(G) Sediments shall be removed from any basin immediately following site stabilization and thereafter in accordance with the specific maintenance plan. Accumulated sediments may have to be removed more frequently if the sediment storage capacity of the forebay or sediment storage area is within the last 10 percent of its available capacity. Sediment removal within a basin shall restore the original capacity and design depth.

(H) If blockage of a basin outlet structure occurs, it may be necessary to dewater the pond for access to the blockage. The dewatering flow must be adequately

filtered prior to discharge into a receiving waterbody to remove suspended solids.

(I) Pools of stagnant water in detention basins indicate failure due to erosion and scouring of the basin bottom, particularly near an inlet device. Such a deficiency must be corrected immediately to prevent a nuisance habitat for insects, especially mosquitoes.

(J) All outlet structures and outflow channels must be inspected annually. Furthermore, extended detention devices should be inspected at least twice per year. Inspections should be accomplished several times during the first six months of operation, especially after rainfall events to check for clogging or, conversely, too rapid of a release.

(K) The grassed areas of any basin must be inspected at least twice per year to check for erosion problems. Problem areas must be reseeded immediately to stabilize exposed soils, thereby preventing erosion and potential clogging of outflow devices.

(L) Inspections of all catch basins on-site shall occur on an annual basis to check for debris removal (sediment and hydrocarbons) and structural integrity or damage. Such deficiency must be corrected immediately.

(M) Repairs or replacement of inlet/outlet structures, riprap channels, fences, or other elements of the facility shall be done within 30 days of deficiency reports. If an emergency situation is imminent then repair/replacement must be done immediately to avert failure or danger to nearby residents.

Section 7—Site Plan

7.1 Map of Existing Site Conditions

The existing conditions site map is useful for reviewing the physical features present at the proposed development site prior to any alteration from land disturbance or construction. This map of predevelopment conditions should at minimum include the information listed below. Additionally, this map should have a scale no smaller than 1 inch = 100 feet with contour intervals no greater than 5 feet. Larger map scales providing greater detail will be acceptable. Individual sheets must not exceed 24 inches by 36 inches.

(A) North arrow with scale.

(B) Existing topography of the site.

(C) Subwatersheds must be clearly delineated and numbered for reference. Within

each subwatershed the following information must be clearly noted: Area in acres, runoff curve number, soil types, hydrologic class, and hydrologic condition.

(D) The stormwater discharge location for each subwatershed must be identified and labeled with peak discharge rates and volumes for the required design storms.

(E) Location of steep slopes, bedrock outcrops, or other significant site constraints.

(F) The applicant's property lines and boundaries of proposed development with bearings and distances.

(G) Abutting property owners and their respective boundaries must be clearly shown along with nearby utility pole numbers and adjacent streets and intersections to facilitate identification of the proposed development.

(H) All perennial and intermittent streams, wetland boundaries, surface water bodies, and areas subject to storm flows or flooding must be indicated. In addition, all coastal features (as identified in the Coastal Resource Management Plan, CRMP), should be delineated where applicable.

(I) The 100-year flood plain boundary with 100-year flood elevations and floodway must be clearly identified consistent with the most recent Federal Emergency Management Agency maps. This may include identifying any applicable flood velocity zones.

(J) The location of existing on-site stormwater structures.

(K) The location and types of easements.

(L) The seasonal high groundwater table in the location of proposed stormwater structures (e.g., detention basins, infiltration trenches, vegetated swales, etc.) as established in accordance with the procedures described in Section 6 of the RI Stormwater Design and Installation Standards Manual.

(M) Location of any required investigative soil pits or test wells.

(N) The delineation of major soil types in the vicinity of the proposed development as identified by the RI Soil Survey or qualified professional.

(O) Location of private and public water supply wells within 100 feet.

(P) Location of existing ISDSs abutting to and within the development site.

(Q) Vegetative cover type including outline of woodland cover.

(R) Existing open space.

(S) Any landmarks, stonewalls, fences, etc.

7.2 Maps of Site Showing Phases of the Proposed Project

The final site map must have all information necessary to evaluate the proposed project after the final construction phase is completed. This map must be at the same scale as the existing conditions site plan map(s) and include the following information.

(A) North arrow with scale.

(B) Subwatersheds must be clearly delineated and numbered for reference. Within each subwatershed the following information must be clearly noted: Area in acres, runoff curve number, soil types, hydrologic class, and hydrologic condition.

(C) Location of proposed structures and individual lots. These lots must be numbered for reference.

(D) Delineation of Individual Sewage Disposal Systems, public and private water supply wells, utility lines, and sub-drains.

(E) Location of all existing and proposed roads, driveways, parking lots, and other impervious surfaces. The total area of all impervious surfaces within each subwatershed must be clearly marked and labeled within the subwatershed boundary.

(F) All new stormwater structures (BMPs), collection and conveyance systems, and remaining portions of existing systems including points of discharge shall be clearly identified.

(G) The peak discharge rate and volume of stormwater flow shall be labeled where stormwater enters and exits all BMPs. Additionally, the final discharge points labeled with peak discharge rates and volumes of stormwater flow must be shown for all subwatersheds.

(H) All water channels or areas subject to storm flows into wetlands, shoreline and coastal features, and tidal waters must be clearly identified whether on-site or in abutting off-site locations.

(I) Design details of all specified stormwater structures (e.g., basins, trenches, etc.) including inlet and outlet structures.

(J) Limits of vegetation clearing and overall site disturbance including delineation of lawns, open space, etc.

(K) The final elevation grade of the proposed development.

(L) Easements are required for installation and access of all stormwater management devices. These must be clearly identified on final plans.

(M) Complete soil erosion and sediment control plans to be implemented in all construction phases along with final site stabilization plans.

(N) Maintenance schedules for all stormwater structures as specified in Section 12 of the RI Stormwater Design and Installation Standards Manual.

7.3 Site Plan Calculations

In addition to the information required for site plans the following information must also be included with the application, where applicable.

(A) The area of each subbasin as identified on final site plans.

(B) The area of impervious surfaces (including all roads, driveways, rooftops, sidewalks, etc.) for each subbasin as identified in 13.5(1) section of the RI Stormwater Design and Installation Standards Manual.

(C) Weighted curve numbers, (CN) as determined by the SCS TR-55 method, for the pervious surfaces within each subbasin as identified in 13.5(1) section of the RI Stormwater Design and Installation Standards Manual.

(D) Invert elevations for all applicable BMPs. In addition, the elevations for permanent and/or flood pool stages, including peak discharge rates for each stage, within all basins are required.

(E) The total volume capacity for all flood control and water quality BMPs (e.g. infiltration basin, detention basins, wet ponds, etc.). Volumes must be segregated into permanent and flood pool stage volumes where applicable. Furthermore, the volumes of all sediment storage (basins, forebays, etc.) areas must also be shown.

(F) Predevelopment and post development peak discharge rates and runoff volumes for the 2-year, 25-year, and 100-year frequency storm events for each subwatershed. The water quality volume must also be calculated for each subwatershed. All relevant variables such as curve numbers and time of concentration, along with the supporting computations and worksheets must be included.

7.4 Narrative Description

As part of the Site Plan, a narrative description should be prepared by the applicant to provide the following information: a brief description of the proposed project; potential water quality and/or hydrologic impacts of the proposed project on surface and/or groundwater resources, existing infrastructure, and/or adjacent properties; and proposed measures or practices to mitigate potential impacts. All affected wetlands,

surface water and groundwater resources, and any significant site constraints affecting the selection of stormwater management practices must be identified.

The following outline is provided as guidance for preparing a narrative description for the Site Plan. Depending on the size and scope of the proposed project, the amount of information required by the permitting agency may vary, therefore it is advised to consult the appropriate permitting agency for specific requirements.

(A) Site description – general topography, soil types, current vegetative composition and relative abundance, identification of major resources (e.g., wetlands, groundwater, surface waters, etc.) name of receiving water(s).

(B) Site input data – watershed characteristics, area of all impervious surfaces, total area of site, annual mean rainfall, runoff coefficients, curve numbers for various land uses, peak discharge rates.

(C) Pollutant loading forecast – predevelopment and post development pollutant mass loadings to demonstrate the removal rates of individual or combined BMPs.

(D) Land use planning and source control plan.

(E) Best Management Practices – identify the type of BMP and justification for selection, including any deviation from the RI Stormwater Design and Installation Standards Manual and the potential effect on pollutant removal efficiency.

(F) Technical feasibility – of BMPs including sizing, location, hydraulic and environmental impacts. Alternatives, which were considered but determined not to be feasible, should also be discussed.

Section 8—Maintenance Agreements

Maintenance agreements shall provide written, contractual documentation, which demonstrates compliance with this section and legal arrangements for the upkeep of stormwater facilities to assure their functionality and safety in accordance with this ordinance.

Maintenance agreements, which describe all maintenance schedules and requirements, must be developed for each stormwater management facility unless the facility is dedicated to and accepted by *[name of municipality]*.

8.1 Recognition of Municipal Inspection Requirements

Maintenance agreements shall include a reasonable and regular schedule for the *[name of municipality]*, or designee, to conduct on-site inspection of the functionality and safety of stormwater management facilities. Inspection schedules shall be based on the

complexity and frequency of maintenance needs and shall be subject to the approval of *[name of municipality]*.

Maintenance agreements shall recognize the authority of *[name of municipality]*, or designee, to conduct on-site inspections of stormwater management facilities should evidence exist that the facility is not being operated in accordance with the maintenance agreement or this ordinance; or should evidence exist that the facility poses an eminent threat to public health, welfare or safety.

8.2 Record Keeping for Maintenance Activities

Maintenance agreements shall include provisions for maintenance record keeping. All activities conducted in accordance with a maintenance agreement must be recorded in a work order and inspection log. Timely updates of the log shall be the responsibility of the stormwater management facility owner or other responsible party pursuant to Section 8.3 of this ordinance. Review of the maintenance and inspection log shall be completed by *[name of municipality]*, or designee, to determine the effectiveness of operation, maintenance and safety activities. Reviews shall occur as part of each on-site inspection. Additional reviews may be made as deemed appropriate by *[name of municipality]* or designee.

8.3 Responsibility for Maintenance to Assure Functionality and Safety

Appropriate maintenance to assure functionality and safety of stormwater management facilities shall be the responsibility the owner or may be assumed by another party via a written contractual arrangement in accordance with Section 8.4 of this ordinance.

8.4 Alterations to Maintenance Agreements

Any alterations in maintenance responsibility or alterations to maintenance agreements must be reviewed and approved by (name of municipal review board). If portions of the land serviced by a stormwater management facility are to be sold, written contractual arrangements shall be made to pass all responsibility of the maintenance agreement to the purchaser and shall be subject to review and approval of (name of municipal review board). All alterations to maintenance agreements shall be recorded in accordance with Section 8.5 of this ordinance.

8.5 Recordation of Maintenance Agreements

All maintenance agreements and alterations to maintenance agreements shall be recorded in the land evidence records of *[name of municipality]*. Copies of all maintenance agreements and alterations to maintenance agreements shall be included in stormwater management plans. Recordation of maintenance agreements in accordance with this ordinance shall be the responsibility of the owner.

Section 9— Policy and Requirements for Performance Surety

A performance bond shall be posted to insure that all stormwater management facilities can be repaired in the event of malfunction. To demonstrate the posting and integrity of the performance bond, a letter of credit shall be provided as part of the stormwater management plan. The letter of credit and posting of the performance bond shall be the responsibility of the property owner.

9.1 Value of the Performance Surety

The value of the performance bond shall be at least equal to the cost of implementing the stormwater management plan, fully.

9.2 Review and Approval of the Performance Surety

The acceptance of the performance bond and letter of credit for the purposes of this ordinance shall be subject to approval of the form, content, amount and manner of execution by the (name of the municipal review board).

9.3 Posting of the Surety with the Subdivision Bond

The amount of a performance bond for the stormwater management plan may be included with the performance bond of a subdivision provided that the performance bond receives full review and approval by (name of municipal review board) in accordance with Section 9.2 of this ordinance. Such a posting shall still require a letter of credit.

9.4 Release of the Performance Surety

The performance bond shall only be released after an on-site inspection of all the stormwater management practices in operating condition as describe in the stormwater management plan, and submission of as-built drawings certified by a registered professional engineer as being in compliance with the stormwater management plan.

9.5 Revocation of the Performance Surety

[Name of municipality] may revoke the performance bond in accordance with Section 10 of this ordinance.

Section 10–-Application Fees

[Name of governing body] shall be empowered to collect fees from permit applicants, which are commensurate with the cost of administering this ordinance.

Section 11—Enforcement

[Name of municipality] shall have the authority and discretion to invoke penalties, whenever a stormwater management facility is not implemented and operated in accordance with its approval and this ordinance. Any penalty invoked shall be in accordance with this section.

11.1 Revocation or Suspension of Approval

The approval of stormwater management plans, stormwater management facility construction and stormwater management facility operation, as subject to this ordinance, may be revoked or suspended, and all work on the project halted for an indefinite time period by (name of municipal review board) or a designee, after written notification is transmitted by the building official to the developer for one or more of the following reasons:

(A) Failure to comply with any condition of an approved plan, or specifications pertaining thereof.

(B) Violation of any requirement of this ordinance.

11.2 Notification of Violation

Whenever there is a failure to comply with the provisions of this ordinance, the [*name of municipality*] shall have the right to notify the applicant/owner that he or she has (5) days from the receipt of the notice to temporarily correct the violations and (30) days from receipt of notice to permanently correct the violations.

Should the applicant/owner fail to take the corrective actions, the city/town of _____ shall then have the right to take whatever actions it deems necessary to correct the violations and to assert a lien on the subject property in an amount equal to the costs of remedial actions. The lien shall be enforced in the manner provided or authorized by law for the enforcement of common law liens on personal property. The lien shall be recorded in the land evidence records of the city/town of _____, and shall incur legal interest from the date of recording. The imposition of any penalty shall not exempt the offender from compliance with the provisions of this ordinance, including revocation of the performance bond or assessment of a lien on the property.

11.3 Hearing

Any owner or responsible party, receiving a written notice of violation, shall be given an opportunity, within a reasonable time frame, for a hearing before the (name of municipal review board) to state their case. If evidence indicates that a violation has not occurred, the (name of municipal review board) shall revoke the notice of violation.

Section 12—Implementation

This ordinance shall take effect upon final passage and approval by the town/city council as appropriate.

Appendix D: Site Stormwater Management Plan Checklist

1. Applicant/Site Information

- Applicant name, legal address, telephone/fax numbers
- Common address and legal description of site
- Site locus map

2. Project Narrative

- Project description and purpose (for existing and proposed conditions)
  - Natural and manmade features at the site, at a minimum, wetlands, watercourses, floodplains, and development (roads, buildings, and other structures)
  - Site topography, drainage patterns, flow paths, and ground cover
  - Impervious area and runoff coefficient
  - Site soils as defined by USDA soil surveys including soil names, map unit, erodibility, permeability, depth, texture, and soil structure
  - Stormwater discharges from the site, including quality and known sources of pollutants and sediment loadings
  - Critical areas, buffers, and setbacks established by the local, state, and federal regulatory authorities
  - Water quality classification of on-site and adjacent waterbodies
  - Identification of any on-site or adjacent waterbodies included on the Connecticut 303(d) list of impaired waters
- Potential stormwater impacts
  - Potential pollution sources (e.g., erosive soils, steep slopes, vehicle fueling, vehicle washing)
  - Types of anticipated stormwater pollutants and the relative or calculated load of each pollutant
  - Summary of calculated pre- and post-development peak flows
  - Summary of calculated pre- and post-development groundwater recharge
- Critical on-site resources
  - Wells, aquifers
  - Wetlands, streams, ponds
  - Public drinking water supplies
- Critical off-site (adjacent to or downstream of site) resources
  - Neighboring land uses
  - Wells, aquifers
  - Wetlands, streams, ponds
  - Public drinking water supplies
- Proposed stormwater management practices
  - Source controls and pollution prevention
  - Alternative site planning and design
  - Stormwater treatment practices
  - Flood control and peak runoff attenuation management practices
- Site plan (for existing and proposed conditions) (see Item 4. below for appropriate format)
  - Topography, drainage patterns, drainage boundaries, and flow paths
  - Locations of stormwater discharges
  - Perennial and intermittent streams
  - USDA soil types
  - Proposed borehole investigations
  - Vegetation and proposed limits of clearing and disturbance
  - Resource protection areas such as wetlands, lakes, ponds, and other setbacks (stream buffers, drinking water well setbacks, septic setbacks, etc.)
  - Roads, buildings, and other structures
  - Utilities and easements
  - Temporary and permanent conveyance systems (grass channels, swales, ditches, storm drains, etc.) including grades, dimensions, and direction of flow
  - Location of floodplain and floodway limits and relationship of site to upstream and downstream properties and drainage systems

- ❑ Location, size, maintenance access, and limits of disturbance of proposed structural stormwater management practices (treatment practices, flood control facilities, stormwater diversion structures, etc.)
- ❑ Final landscaping plans for structural stormwater management practices and site revegetation
- ❑ Locations of non-structural stormwater management practices (i.e., source controls)

✎ Construction Schedule

3. Calculations

✎ Pollutant Reduction
- ❑ Water Quality Volume (WQV)
- ❑ Water Quality Flow (WQF)
- ❑ Pollutant Loads

✎ Groundwater Recharge
- ❑ Groundwater Recharge Volume (GRV)

✎ Runoff Capture (for new stormwater discharges to tidal wetlands)
- ❑ Runoff Capture Volume

✎ Peak Flow Control
- ❑ Hydrologic and hydraulic design calculations (pre- and post-development conditions)
  - Description of the design storm frequency, intensity, and duration
  - Watershed map with locations of design points and watershed areas (acres) for runoff calculations
  - Time of concentration (and associated flow paths)
  - Imperviousness of the entire site and each watershed area
  - NRCS runoff curve numbers or volumetric runoff coefficients
  - Peak runoff rates, volumes, and velocities for each watershed area (24-hour storm)
    - ➢ Stream Channel Protection: 2-year frequency ("over-control" of 2-year storm)
    - ➢ Conveyance Protection: 10-year frequency
    - ➢ Peak Runoff Attenuation: 10-year, 25-year, and 100-year frequency (other as required by local review authority)
    - ➢ Emergency Outlet Sizing: safely pass the 100-year frequency or larger storm.
  - Hydrograph routing calculations
  - Culvert capacities
  - Infiltration rates, where applicable
  - Dam breach analysis, where applicable
  - Documentation of sources for all computation methods and field test results
- ❑ Downstream analysis, where detention is proposed
- ❑ Drainage systems and structures

4. Design Drawings and Specifications

✎ Recommended size (no larger than 24" x 36" and no smaller than 8-1/2" x 11")

✎ Recommended scale (maximum scale of 1" = 40', larger scales up to 1" = 100' may be used to represent overall site development plans or for conceptual plans)

✎ Design details (cross-sections, elevation views, and profiles as necessary)

✎ Specifications
- ❑ Construction materials
- ❑ Stormwater control product designations (if applicable)
- ❑ Methods of installation
- ❑ Reference to applicable material and construction standards

✎ Cover sheet with sheet index

✎ Title block

✎ Legend

✎ North arrow

- Property boundary of subject property (including parcels, or portions thereof, of abutting land and roadways within one hundred feet of the property boundary)
- Site locus map (recommended scale 1" = 1,000') with a north arrow
- Seals of a licensed professionals (original design plans, calculations, and reports)
- Survey plans
  - Prepared according to the *Minimum Standards for Surveys and Maps in Connecticut*
  - The class of survey represented on the plan
  - Stamped by a professional land surveyor
  - Depict topography at contour intervals of two feet
  - The referenced or assumed elevation datum
  - Two (2) benchmarks on the site within one hundred feet of the proposed construction
  - Outside limits of disturbances
  - Plan references

5. Construction Erosion and Sediment Controls

- Erosion and sediment control plan that complies with the requirements of the current version of *Connecticut Guidelines for Soil Erosion and Sediment Control, DEP Bulletin 34*.

6. Supporting Documents and Studies

Provide other sources of information used in the design of construction and post-construction stormwater controls for the site development, as applicable:

- Soil maps, borings/test pits
- Infiltration test results
- Groundwater impacts for proposed infiltration structures
- Reports on wetlands and other surface waters (including available information such as Maximum Contaminant Levels [MCLs], Total Maximum Daily Loads [TMDLs], 303(d) or 305(b) listings, etc.)
- Water quality impacts to receiving waters and biological/ecological studies
- Flood study/calculations

7. Other Required Permits

- Evidence of acquisition of all applicable federal, state, and local permits or approvals (e.g., copies of DEP permit registration certificates, DEP Dam Safety Registration certificate for stormwater impoundments, DPH approval letter for stormwater discharges within 100 feet of a watercourse within a public water supply watershed or aquifer protection area, local approval letters, etc.)

8. Operation and Maintenance

- Detailed inspection and maintenance requirements/tasks
- Inspection and maintenance schedules
- Parties legally responsible for maintenance (name, address, and telephone number)
- Provisions for financing of operation and maintenance activities
- As-built plans of completed structures
- Letter of compliance from designer
- Post-construction documentation to demonstrate compliance with maintenance activities.

Appendix E: Maintenance Inspection Checklist
Stormwater Ponds and Wetlands

Project/Location: _____

"As Built" Plans Available? _____

Date/Time: _____

Days Since Previous Rainfall and Rainfall Amount: _____

Inspector: _____

Maintenance Item	Satisfactory	Unsatisfactory	Comments
1. Embankment and Emergency Spillway			
• Vegetation and ground cover adequate			
• Embankment erosion			
• Animal burrows			
• Unauthorized planting			
• Cracking, bulging, or sliding of embankment/dam			
a. Upstream face			
b. Downstream face			
c. At or beyond toe			
d. Emergency spillway			
• Pond, toe & chimney drains clear and functioning			
• Seeps/leaks on downstream face			
• Slope protection or riprap failure			
• Vertical/horizontal alignment of top of dam "As-Built"			
• Emergency spillway clear of obstructions and debris			
• Other (specify)			
2. Riser and Principal Spillway			
• Low flow orifice obstructed			
• Low flow trash rack obstructed with debris			
• Weir trash rack obstructed with debris			
• Excessive sediment accumulation insider riser			
• Concrete/masonry condition riser and barrels			
a. Cracks or displacement			
b. Minor spalling (<1")			
c. Major spalling (rebars exposed)			
d. Joint failures			
e. Water tightness			
• Metal pipe condition			
• Control valve			
a. Operational/exercised			

Maintenance Item	Satisfactory	Unsatisfactory	Comments
b. Chained and locked			
• Pond drain valve			
a. Operational/exercised			
b. Chained and locked			
• Outfall channels functioning			
• Other (specify)			
3. Permanent Pool (Wet Ponds)			
• Undesirable vegetative growth			
• Floating or floatable debris removal required			
• Visible pollution			
• Shoreline problem			
• Other (specify)			
4. Sediment Forebay			
• Sedimentation noted			
• Greater than 50% of storage volume remaining			
5. Dry Pond Areas			
• Vegetation coverage adequate			
• Undesirable vegetative growth			
• Undesirable woody vegetation			
• Low flow channels clear of obstructions			
• Standing water or wet spots			
• Sediment and/or trash accumulation			
• Other (specify)			
6. Condition of Outfalls			
• Riprap failures			
• Slope erosion			
• Storm drain pipes			
• Endwalls/Headwalls			
• Other (specify)			
7. Other			
• Complaints from residents (odors, insects, other)			
• Aesthetics (graffiti, algae, other)			
• Conditions of maintenance access routes			
• Signs of hydrocarbon build-up			
• Any public hazards (specify)			
8. Wetland Vegetation			
• Vegetation healthy and growing			
• Wetland maintaining 50% surface area coverage of wetland plants after the second growing season. (If unsatisfactory, reinforcement plantings needed)			
• Survival of desired wetland plant species distribution according to landscaping plan?			
• Evidence of invasive species			

Maintenance Item	Satisfactory	Unsatisfactory	Comments
• Maintenance of adequate water depths for desired wetland plant species.			
• Harvesting of emergent plantings needed			
• Have sediment accumulations reduced pool volume significantly or are plants "choked with sediment.			
• Other (specify)			
Actions to Be Taken: **To Be Completed By (Date):**			

Source: Adapted from Watershed Management Institute, Inc. 1997. *Operation, Maintenance, and Management of Stormwater Management Systems*. In cooperation with U.S. Environmental Protection Agency, Office of Water. Washington, D.C.

Appendix E: Maintenance Inspection Checklist
Infiltration Basins and Trenches

Project/Location: _____

"As Built" Plans Available? _____

Date/Time: _____

Days Since Previous Rainfall and Rainfall Amount: _____

Inspector: _____

Maintenance Item	Satisfactory	Unsatisfactory	Comments
1. Debris Cleanout			
• Basin bottom or trench surface clear of debris			
• Inlet/Inflow pipes clear of debris			
• Overflow spillway clear of debris			
• Outlet clear of debris			
2. Sediment Traps or Forebays			
• Sedimentation noted			
• Greater than 50% of storage volume remaining			
3. Vegetation (Basins)			
• Mowing performed as necessary			
• No evidence of erosion			
4. Dewatering			
• Basin/Trench dewaters between storms			
• Drawdown time does not exceed 36 to 48 hours			
5. Sediment Accumulation			
• Approximate depth of accumulated sediment			
6. Inlets			
• Good condition			
• No evidence of erosion			
7. Outlet/Overflow Spillway			
• Good condition, no need for repair			
• No evidence of erosion			
8. Aggregate Repairs (Trench)			
• Surface of aggregate clean			
• Top layer of stone does not need replacement			
• Trench does not need rehabilitation			
9. Structural Repairs			
• Embankment in good repair			
• Site slopes are stable			
• No evidence of erosion			

Maintenance Item	Satisfactory	Unsatisfactory	Comments
10. Fences/Access Repairs			
• Fences in good condition			
• No damage which would allow undesired entry			
• Access point in good condition			
• Locks and gate function property			
Actions to Be Taken: **To Be Completed By (Date):**			

Source: Adapted from Watershed Management Institute, Inc. 1997. *Operation, Maintenance, and Management of Stormwater Management Systems.* In cooperation with U.S. Environmental Protection Agency, Office of Water. Washington, D.C.

Appendix E: Maintenance Inspection Checklist
Filtering Practices – Sand and Organic Filters

Project/Location: _____

"As Built" Plans Available? _____

Date/Time: _____

Days Since Previous Rainfall and Rainfall Amount: _____

Inspector: _____

Maintenance Item	Satisfactory	Unsatisfactory	Comments
1. Debris Cleanout			
• Filtration facility clean of debris			
• Inlet and outlets clear of debris			
2. Oil and Grease			
• No evidence of filter surface clogging			
• Activities in drainage area minimize oil and grease entry			
3. Vegetation			
• Contributing drainage area stabilized			
• No evidence of erosion			
• Area mowed and clipping removed			
4. Water Retention			
• Water holding chambers at normal pool			
• Filter chamber dewaters between storms			
• No evidence of leakage			
5. Sediment Accumulation			
• Approximate depth of accumulated sediment			
• Depth of sediment in forebay or sump should not be more than 12 inches or 10 percent of the pretreatment volume			
• Sediment accumulation on filter bed does not exceed 1" or drawdown time does not exceed 36 to 48 hours			
6. Structural Components			
• No evidence of structural deterioration			
• Grates are in good condition			
• No evidence of spalling or cracking of structural parts			
7. Outlet/Overflow Spillway			
• Good condition, no need for repairs			
• No evidence of erosion (if draining into a natural channel)			
8. Overall Function of Facility			
• No evidence of flow bypassing facility			
• No noticeable odors outside facility			

Actions to Be Taken: **To Be Completed By (Date):**			

Source: Adapted from Watershed Management Institute, Inc. 1997. *Operation, Maintenance, and Management of Stormwater Management Systems.* In cooperation with U.S. Environmental Protection Agency, Office of Water. Washington, D.C.

Appendix E: Maintenance Inspection Checklist
Filtering Practices - Bioretention

Project/Location: _____

"As Built" Plans Available? _____

Date/Time: _____

Days Since Previous Rainfall and Rainfall Amount: _____

Inspector: _____

Maintenance Item	Satisfactory	Unsatisfactory	Comments
1. Debris Cleanout			
• Bioretention and contributing areas clean of debris			
• No dumping of yard wastes into practice			
• Litter (branches, etc.) has been removed			
2. Vegetation			
• Plant height not less than design water depth			
• Fertilized per specifications			
• Plant composition according to approved plans			
• No placement of inappropriate plants			
• Grass height not greater than 6 inches			
• No evidence of erosion			
3. Check Dams/Energy Dissipaters/Sumps			
• No evidence of sediment buildup			
• No evidence of erosion at downstream toe of drop structure			
4. Dewatering			
• Dewaters between storms			
• No evidence of standing water			
5. Sediment Accumulation			
• Approximate depth of accumulated sediment			
• Depth of sediment in forebay or sump should not be more than 12 inches or 10 percent of the pretreatment volume			
• Sediment accumulation on filter bed does not exceed 1" or drawdown time does not exceed 36 to 48 hours			
6. Outlet/Overflow Spillway			
• Good condition, no need for repair			
• No evidence of erosion			
• No evidence of any blockages			
7. Integrity of Filter Bed			
• Filter bed has not been blocked or filled inappropriately			
Actions to Be Taken:			

To Be Completed By (Date):

Source: Adapted from Watershed Management Institute, Inc. 1997. *Operation, Maintenance, and Management of Stormwater Management Systems.* In cooperation with U.S. Environmental Protection Agency, Office of Water. Washington, D.C.

Appendix E: Maintenance Inspection Checklist
Water Quality Swales

Project/Location: _____

"As Built" Plans Available? _____

Date/Time: _____

Days Since Previous Rainfall and Rainfall Amount: _____

Inspector: _____

Maintenance Item	Satisfactory	Unsatisfactory	Comments
1. Debris Cleanout			
• No excessive trash and debris in contributing areas, forebay, or channel			
2. Check Dams or Energy Dissipators			
• No evidence of flow going around structures			
• No evidence of erosion at downstream toe			
3. Vegetation			
• Mowing performed as necessary (to maintain grass height of 4 to 6 inches during growing season)			
• No evidence of erosion (channel bottom or side slopes)			
• Fertilized per specification			
4. Dewatering			
• Dewaters between storms (dry swales)			
5. Sediment Accumulation			
• Approximate depth of accumulated sediment			
• Sediment accumulation is less than 25% of forebay or channel capacity (cleaning recommended otherwise)			
6. Outlet/Overflow Spillway			
• Good condition, no need for repairs			
• No evidence of erosion			
Actions to Be Taken: **To Be Completed By (Date):**			

Source: Adapted from Watershed Management Institute, Inc. 1997. *Operation, Maintenance, and Management of Stormwater Management Systems.* In cooperation with U.S. Environmental Protection Agency, Office of Water. Washington, D.C.

Appendix F: Glossary

Some definitions in this glossary are adapted from definitions in applicable sections of the _____, as well as related guidance documents such as the _____. Refer to these sources for complete definitions.

Advanced Treatment – Pollutant removal techniques typically used in drinking water treatment processes but with potential for application as advanced treatment options for stormwater. These treatment techniques include ion exchange, reverse osmosis, disinfection, ultrafiltration, alum injection, and use of water-soluble anionic polyacrylamide (PAM).

Agricultural Runoff – Runoff from land utilized for agricultural practices including growing crops and raising livestock.

Alternative Site Design – Innovative site design practices have been developed as alternatives to traditional development to control stormwater pollution and protect the ecological integrity of developing watersheds. Research has demonstrated that alternative site design can reduce impervious cover, runoff volume, pollutant loadings, and development costs when compared to traditional development.

Alum Injection – Injection of aluminum phosphate (alum), which has been used extensively as a flocculent in pond and lake management applications, for reducing concentrations of fine sediment and phosphorous in stormwater discharges to eutrophic water bodies.

Aquatic Bench – A ten-foot wide bench located around the inside perimeter of a permanent pool that is normally vegetated with aquatic plants to provide pollutant removal.

Aquifer – A porous water-bearing formation of permeable rock, sand or gravel capable of yielding economically significant quantities of groundwater.

Baseflow – The portion of streamflow that is not due to storm runoff but is the result of groundwater discharge or discharge from lakes or similar permanent impoundments of water.

Biochemical Oxygen Demand (BOD) – A measure of the quantity of organic material that can be decomposed through oxidation by micro-organisms.

Bioretention – A practice to manage and treat stormwater runoff by using a specially designed planting soil bed and planting materials to filter runoff stored in a shallow depression. The areas consist of a mix of elements each designed to perform different functions in the removal of pollutants and attenuation of stormwater runoff.

Building Setbacks – The distance between a structure and a property boundary (front, rear, or side) of the lot on which the structure is located.

Catch Basin Inserts – A structure, such as a tray, basket, or bag that typically contains a pollutant removal medium (i.e., filter media) and a method for suspending the structure in the

catch basin. They are placed directly inside of existing catch basins where stormwater flows into the catch basin and is treated as it passes through the structure.

Catch Basin – A structure placed below grade to conduct water from a street or other paved surface to the storm sewer.

Check Dams - Small temporary dams constructed across a swale or drainage ditch to reduce the velocity of concentrated stormwater flows.

Chemical Oxygen Demand (COD) - A measure of the amount of organic material that can be chemically oxidized.

Cisterns – Containers that store larger quantities of rooftop stormwater runoff and may be located above or below ground. Cisterns can also be used on residential, commercial, and industrial sites. Also see Rain Barrel.

Coastal Area - As defined in CGS Section 22a-94(a), land and water within the towns listed in Table 1-2 of this manual.

Coastal Boundary - As defined in CGS Section 22a-94(b), a region within the coastal area delineated by the contour elevation of the one hundred year frequency coastal flood zone, as defined and determined by the National Flood Insurance Act, or a one thousand foot linear setback measured from the mean high water mark in coastal waters, or a one thousand foot linear setback measured from the inland boundary of tidal wetlands mapped under section 22a-20, whichever is farthest inland.

Combined Sewer Overflows (CSOs) – Combined sewers collect both stormwater runoff and sanitary wastewater in a single set of sewer pipes. When combined sewers do not have enough capacity to carry all the runoff and wastewater or the receiving water pollution control plant cannot accept all the combined flow, the combined wastewater overflows from the collection system into the nearest body of water, creating a CSO.

Darcy's Law – An equation stating that the rate of fluid flow through a porous medium is proportional to the potential energy gradient within the fluid. The constant of proportionality is the hydraulic conductivity, which is a property of both the porous medium and the fluid moving through the porous medium.

Deep Sump Catch Basins - Storm drain inlets that typically include a grate or curb inlet and a sump to capture trash, debris and some sediment and oil and grease. Also known as an oil and grease catch basin.

Deicers - Materials applied to reduce icing on paved surfaces. These consist of salts and other formulated materials that lower the melting point of ice, including sodium chloride, calcium chloride, calcium magnesium acetate, and blended products consisting of various combinations of sodium, calcium, magnesium, and chloride, as well as other constituents.

Deicing Constituents – Additives included in deicing materials to prevent caking and inhibit corrosion.

Design Storm – Precipitation event for which the capacity of a best management practice is sized and designed. Design storms are expressed in terms of Type III, 24-hour events (i.e., 1-year, 2-year, 10-year, 25-year and 100-year storms) as defined by the U.S. Department of Commerce and Weather Bureau (see Table 7.3-2).

Dissolved Pollutants – Non-particulate pollutants typically removed through removal mechanisms such as adsorption, biological uptake, chemical precipitation or ion exchange.

Downstream Analysis - Calculation of peak flows, velocities, and hydraulic effects at critical downstream locations to ensure that proposed projects do not increase post-development peak flows and velocities at these locations.

Dry Detention Pond – Stormwater basin designed to capture, temporarily hold, and gradually release a volume of stormwater runoff to attenuate and delay stormwater runoff peaks. Dry detention ponds provide water quantity control (peak flow control and stream channel protection) as opposed to water quality control. Also known as "dry ponds" or "detention basins".

Dry Well - Small excavated pits or trenches filled with aggregate that receive clean stormwater runoff primarily from building rooftops. Dry wells function as infiltration systems to reduce the quantity of runoff from a site. The use of dry wells is applicable for small drainage areas with low sediment or pollutant loadings and where soils are sufficiently permeable to allow reasonable rates of infiltration.

Emergency Spillway – Auxiliary outlet to a water impoundment that transmits floodwater exceeding the capacity of the primary spillway.

Erosion – The wearing away of land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep.

Erosion and Sediment Control – A device placed, constructed on, or applied to the landscape that prevents or curbs the detachment of soil, its movement, and/or deposition.

Failing Septic System – An on-site wastewater disposal system that discharges effluent into the ground at concentrations that exceed water quality standards. Failing systems can be significant sources of nutrients, especially nitrogen, and microbial pathogens to both surface water and groundwater.

Filter Strip – A strip or area of vegetation for removing sediment, organic material, nutrients and chemicals from runoff or wastewater. They are typically located downgradient of stormwater outfalls and level spreaders to reduce flow velocities and promote infiltration/filtration.

Filtering Practices - Practices that capture and store stormwater runoff and pass it through a filtering media such as sand, organic material, or soil for pollutant removal. Stormwater filters are primarily water quality control devices designed to remove particulate pollutants and, to a lesser degree, bacteria and nutrients.

Floodplain – Any land susceptible to being inundated by water, usually adjacent to a stream, river or water body and usually associated with a particular design flooding frequency (e.g., 100-year floodplain).

Flow Splitter – An engineered, hydraulic structure designed to divert a percentage of stormwater to a treatment practice located outside of the primary channel or to direct stormwater to a parallel pipe system or to bypass a portion of baseflow around a treatment practice.

Fourth Order Stream – Stream order indicates the relative size of a stream based on Strahler's (1957) method. Streams with no tributaries are first order streams, represented as the start of a solid line on a 1:24,000 USGS Quadrangle Sheet. A second order stream is formed at the confluence of two first order streams, and so on.

Fresh-tidal Wetland - a tidal wetland with an annual average salinity of less than 0.5 parts per thousand.

Full Sedimentation Design - Stormwater filter system design involving storage and pretreatment of the entire water quality volume.

Grass Drainage Channels - Traditional vegetated open channels, typically trapezoidal, triangular, or parabolic in shape, whose primary function is to provide non-erosive conveyance, typically up to the 10-year frequency design flow. They provide limited pollutant removal through filtration by grass or other vegetation, sedimentation, biological activity in the grass/soil media, as well as limited infiltration if underlying soils are pervious.

Groundwater Recharge – The process by which water that seeps into the ground, eventually replenishing groundwater aquifers and surface waters such as lakes, streams, and the oceans. This process helps maintain water flow in streams and wetlands and preserves water table levels that support drinking water supplies.

Groundwater Recharge Volume (GRV) - The post-development design recharge volume (i.e., on a storm event basis) required to minimize the loss of annual pre-development groundwater recharge. The GRV is determined as a function of annual pre-development recharge for site-specific soils or surficial materials, average annual rainfall volume, and amount of impervious cover on a site.

Heavy Metals - Metals such as copper, zinc, barium, cadmium, lead, and mercury, which are natural constituents of the Earth's crust. Heavy metals are stable and persistent environmental contaminants since they cannot be degraded or destroyed.

Hydraulic Conductivity – The rate at which water moves through a saturated porous media under a unit potential-energy gradient. It is a measure of the ease of water movement in soil and

is a function of the fluid as well as the porous media through which the fluid is moving. The field infiltration rate can be approximated by the saturated hydraulic conductivity.

Hydraulic Head – The kinetic or potential energy of a unit weight of water expressed as the vertical height of water above a reference datum.

Hydrocarbons – Inorganic compounds consisting of carbon and hydrogen, including petroleum hydrocarbons derived from crude oil, natural gas, and coal.

Hydrodynamic Separators – A group of stormwater treatment technologies designed to remove large particle total suspended solids and large oil droplets, consisting primarily of cylindrical-shaped devices that are designed to fit in or adjacent to existing stormwater drainage systems. The most common mechanism used in these devices is vortex-enhanced sedimentation, where stormwater enters as tangential inlet flow into the side of the cylindrical structure. As the stormwater spirals through the chamber, the swirling motion causes the sediments to settle by gravity, removing them from the stormwater.

Hydrograph – A graph showing the variation in discharge or depth of a stream of water over time.

Hydrologic Cycle – The distribution and movement of water between the earth's atmosphere, land, and water bodies.

Hydrologic Zones – Planting zones that reflect the degree and duration of inundation by water, consisting of a deep water pool, shallow water bench, shoreline fringe, riparian fringe, floodplain terrace, and upland slopes.

Illicit Discharges - Unpermitted discharges to waters of the state that do not consist entirely of stormwater or uncontaminated groundwater except certain discharges identified in the DEP Phase II Stormwater General Permit.

Impaired Waters [303(d) List] – Those water bodies not meeting water quality standards. This list of impaired waters within each state is referred to as the "303(d) List" and is prepared pursuant to Section 303(d) of the Federal Clean Water Act.

Impervious Surfaces – Surfaces that cannot infiltrate rainfall, including rooftops, pavement, sidewalks, and driveways.

Infiltration Practices – Stormwater treatment practices designed to capture stormwater runoff and infiltrate it into the ground over a period of days, including infiltration trenches and infiltration basins.

Infiltration Rate – A soil characteristic determining or describing the maximum rate at which water can enter the soil under specific conditions.

Instantaneously Mixed Reservoir – A hypothetical model of a natural water body or impoundment in which the contents are sufficiently well-mixed as to be uniformly distributed.

Integrated Pest Management (IPM) – An approach to pesticide usage that combines monitoring; pest trapping; establishment of action thresholds; use of resistant varieties and cultivars; cultural, physical, and biological controls; and precise timing and application of pesticide treatments to avoid the use of chemical pesticides when possible and use the least toxic pesticide that targets the pest of concern, when pesticide usage is unavoidable.

Low Flow Orifice – Principal outlet of a stormwater treatment practice to convey flows above the permanent pool elevation.

Low Impact Development (LID) - Low impact development is a site design strategy intended to maintain or replicate predevelopment hydrology through the use of small-scale controls integrated throughout the site to manage runoff as close to its source as possible.

Media Filters – These devices consist of media, such as pleated fabric, activated charcoal, perlite, amended sand and perlite mixes, or zeolite placed within filter cartridges that are typically enclosed in concrete vaults. Stormwater is passed through the media, which traps particulates and/or soluble pollutants

Micropool – A smaller permanent pool that is incorporated into the design of a larger stormwater pond to avoid resuspension of particles.

Municipal Separate Storm Sewer System (MS4) - conveyances for stormwater, including, but not limited to, roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains owned or operated by any municipality, sewer or sewage district, fire district, State agency or Federal agency and discharging directly to surface waters of the state.

Native Plants - Plants that are adapted to the local soil and rainfall conditions and that require minimal watering, fertilizer, and pesticide application.

Nitrate - One of the forms of nitrogen found in aquatic ecosystems. It is produced during nitrification and denitrification by bacteria. Nitrate is the most completely oxidized state of nitrogen commonly found in water, and is the most readily available state utilized for plant growth.

Nitrite - A form of nitrogen that is the end-product of nitrification, which is produced by Nitrobacter spp. Nitrate is also the initial substrate for denitrification.

Nonpoint Source Pollution – Pollution caused by diffuse sources that are not regulated as point sources and are normally associated with precipitation and runoff from the land or percolation.

Non-Routine Maintenance - Corrective measures taken to repair or rehabilitate stormwater controls to proper working condition. Non-routine maintenance is performed as needed, typically in response to problems detected during routine maintenance and inspections.

Non-Structural Controls – Pollution control techniques, such as management actions and behavior modification that do not involve the construction or installation of devices.

Oil/Particle Separators - Consist of one or more chambers designed to remove trash and debris and to promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater runoff. Oil/particle separators are typically designed as off-line systems for pretreatment of runoff from small impervious areas, and therefore provide minimal attenuation of flow. Also called oil/grit separators, water quality inlets, and oil/water separators.

Open Space Development - A compact form of development that concentrates density in one portion of the site in exchange for reduced density elsewhere. Also known as cluster or conservation development.

Optical Brighteners - Fluorescent white dyes that are additives in laundry soaps and detergents and are commonly found in domestic wastewater.

Partial Sedimentation Design - Stormwater filter system design involving storage and pretreatment of a portion of the water quality volume.

Peak Flow Control - Criteria intended to address increases in the frequency and magnitude of a range of potential flood conditions resulting from development and include stream channel protection, conveyance protection, peak runoff attenuation, and emergency outlet sizing.

Performance Monitoring – Collection of data on the effectiveness of individual stormwater treatment practices.

Permanent (Wet) Pool – An area of a detention basin or flood control project that has a fixed water surface elevation due to a manipulation of the outlet structure.

Permeable Paving Materials - Materials that are alternatives to conventional pavement surfaces and are designed to increase infiltration and reduce stormwater runoff and pollutant loads. Alternative materials include modular concrete paving blocks, modular concrete or plastic lattice, cast-in-place concrete grids, and soil enhancement technologies. Stone, gravel, and other low-tech materials can also be used as alternatives for low traffic applications such as driveways, haul roads, and access roads

Phase II Stormwater – The second phase of the NPDES program which specifically targets certain regulated small MS4s and construction activity disturbing between one and five acres of land.

Plug Flow – A hypothetical model of a natural water body or impoundment in which advection dominates (i.e., substances are discharged in the same sequence in which they enter).

Point Source - any discernible, confined and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock,

concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged.

Porous Pavement – Porous pavement is similar to conventional asphalt or concrete but is formulated to have more void space for greater water passage through the material.

Pretreatment – Techniques used in stormwater management to provide storage and removal of coarse materials, floatables, or other pollutants before the primary treatment practice.

Primary Stormwater Treatment Practice – Stormwater treatment practices that are capable of providing high levels of water quality treatment as stand-alone devices; can be grouped into five major categories – stormwater ponds, stormwater wetlands, infiltration practices, filtering practices, and water quality swales.

Principal Spillway – The primary pipe or weir that carries baseflow and storage flow through the embankment.

Quality Assurance Project Plan (QAPP) - A document describing the planning, implementation, and assessment procedures for a particular project, as well as any specific quality assurance and quality control activities. It integrates all the technical and quality assurance and control aspects of the project to provide a comprehensive plan for obtaining the type and quality of environmental data and information needed for a specific decision or use.

Rain Barrels - Barrels designed to retain small volumes of runoff for reuse for gardening and landscaping. They are applicable to residential, commercial, and industrial sites and can be incorporated into a site's landscaping plan. The size of the rain barrel is a function of rooftop surface area and the design storm to be stored.

Rain Garden - Functional landscape elements that combine plantings in depressions that allow water to pool for only a few days after a rainfall then be slowly absorbed by the soil and plantings.

Rainwater Harvesting –The collection and conveyance of rainwater from roofs and storage in either rain barrels or cisterns. Depending on the type and reuse of the rainwater, purification may be required prior to distribution of the rainwater for reuse. Harvested rainwater can be used to supply water for drinking, washing, irrigation, and landscaping.

Rational Equation – An equation that may be appropriate for estimating peak flows for small urbanized drainage areas with short times of concentration, but does not estimate runoff volume and is based on many restrictive assumptions regarding the intensity, duration, and aerial coverage of precipitation.

Retention (or Residence) Time - The average length of time that a "parcel" of water spends in a stormwater pond or other water body.

Riser – A vertical pipe extending from the bottom of a pond that is used to control the discharge rate for a specified design storm.

Routine Maintenance - Maintenance performed on a regular basis to maintain proper operation and aesthetics.

Runoff Capture Volume (RCV) - The runoff capture volume is equivalent to the water quality volume (WQV) and is the stormwater runoff volume generated by the first inch of rainfall on the site.

Safety Bench – A flat area above the permanent pool and surrounding a stormwater pond or wetland to provide separation from the pool and adjacent slopes.

Seasonally High Groundwater Table – The highest elevation of the groundwater table typically observed during the year.

Secondary Stormwater Treatment Practices - Stormwater treatment practices that may not be suitable as stand-alone treatment because they either are not capable of meeting the water quality treatment performance criteria or have not yet received the thorough evaluation needed to demonstrate the capabilities for meeting the performance criteria.

Sediment Chamber or Forebay – A underground chamber or surface impoundment (i.e., forebay) designed to remove sediment and/or floatables prior to a primary or other secondary stormwater treatment practice.

Sensitive Watercourse – Streams, brooks, and rivers that are classified by DEP as Class A (fishable, swimmable, and potential drinking water), as well as their tributary watercourses and wetlands, that are high quality resources that warrant a high degree of protection.

Shallow Marsh – The portion of a stormwater wetland that consists of aquatic vegetation within a permanent pool ranging in depth from 6" to 18" during normal conditions.

Shared Parking – A strategy that reduces the number of parking spaces needed by allowing adjacent land uses with different peak parking demands to share parking lots.

Site Planning and Design – Techniques of engineering and landscape design that maintaining predevelopment hydrologic functions and pollutant removal mechanisms to the extent practical.

Site Stormwater Management Plan - Plan describing the potential water quality and quantity impacts associated with a development project both during and after construction. It also identifies selected source controls and treatment practices to address those potential impacts, the engineering design of the treatment practices, and maintenance requirements for proper performance of the selected practices.

Soil Infiltration Capacity – The maximum rate at which water can infiltrate into the soil from the surface.

Soluble Phosphorus - Soluble phosphorus is present predominantly as the ionic species orthophosphate and is thought to be the form readily taken up by plants, i.e., "bioavailable."

Source Controls - Practices to limit the generation of stormwater pollutants at their source.

Stormwater – Water consisting of precipitation runoff or snowmelt.

Stormwater Hotspots - Land uses or activities with potential for higher pollutant loads.

Stormwater Pollution Prevention Plan (SWPPP) - Identifies potential sources of pollution and outlines specific management activities designed to minimize the introduction of pollutants into stormwater.

Stormwater Ponds –Vegetated ponds that retain a permanent pool of water and are constructed to provide both treatment and attenuation of stormwater flows.

Stormwater Retrofits – Modifications to existing development to incorporate source controls and structural stormwater treatment practices to remedy problems associated with and improve water quality mitigation functions of older, poorly designed, or poorly maintained stormwater management systems.

Stormwater Treatment Practices – Devices constructed for primary treatment, pretreatment or supplemental treatment of stormwater.

Stormwater Treatment Train - Stormwater treatment practices, as well as site planning techniques and source controls, combined in series to enhance pollutant removal or achieve multiple stormwater objectives.

Stormwater Wetlands – Shallow, constructed pools that capture stormwater and allow for the growth of characteristic wetland vegetation.

Street Sweepers – Equipment to remove particulate debris from roadways and parking lots, including mechanical broom sweepers, vacuum sweepers, regenerative air sweepers and dry vacuum sweepers.

Structural Controls – Devices constructed for temporary storage and treatment of stormwater runoff.

Submerged Aquatic Vegetation (SAV) – Includes rooted, vascular, flowering plants that live permanently submerged below the water in coastal, tidal and navigable waters.

Synthetic Organic Chemicals – Chemicals that contain carbon, but are not naturally occurring.

Technology Acceptance and Reciprocity Partnership (TARP) – TARP was formed by the states of California, Illinois, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Virginia to development standard protocols for the collection and evaluation of performance data for new environmental technologies.

Tidal Wetland – As defined in CGS Section 22a-29(2), those areas that border on or lie beneath tidal waters whose surface is at or below an elevation of one foot above local extreme

high water and upon which may grow or be capable of growing some, but not necessarily all, of a list of specific plant species.

Time of Concentration –The time required for water to flow from the most distant point to the downstream outlet of a site. Runoff flow paths, ground surface slope and roughness, and channel characteristics affect the time of concentration.

Total Kjeldahl Nitrogen (TKN) – The sum of the ammonia nitrogen and the organic bounded nitrogen; nitrates and nitrites are not included.

Total Maximum Daily Load (TMDL) - A calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources, including a margin of safety.

Total Nitrogen – The sum of total Kjeldahl nitrogen, nitrate, and nitrite. Nitrogen is typically the growth-limiting nutrient is estuarine and marine systems.

Total Organic Carbon – A measure of the organic matter content. The amount of organic matter content affects biogeochemical processes, nutrient cycling, biological availability, chemical transport and interactions and also has direct implications in the planning of wastewater treatment and drinking water treatment.

Total Phosphorus – Sum of orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate. Phosphorus is typically the growth-limiting nutrient is freshwater systems.

Total Suspended Solids – The total amount of particulate matter that is suspended in the water column.

Technical Release Number 55 (TR-55) – A watershed hydrology model developed by the Soil Conservation Service (now Natural Resource Conservation Service) used to calculate runoff volumes, peak flows, and simplified routing for storm events through ponds.

Trash Rack – A structural device (e.g., screen or grate) used to prevent debris from entering a spillway, channel, drain, pump or other hydraulic structure.

Underground Detention Facilities - Vaults, pipes, tanks, and other subsurface structures designed to temporarily store stormwater runoff for water quantity control and to drain completely between runoff events. They are intended to control peak flows, limit downstream flooding, and provide some channel protection.

Underground Infiltration Systems – Structures designed to capture, temporarily store, and infiltrate the water quality volume over several days, including premanufactured pipes, vaults, and modular structures. Used as alternatives to infiltration trenches and basins for space-limited sites and stormwater retrofit applications.

Urban Stormwater Runoff - Stormwater runoff from developed areas.

Vegetated Buffer - An area or strip of land in permanent undisturbed vegetation adjacent to a water body or other resource that is designed to protect resources from adjacent development during construction and after development by filtering pollutants in runoff, protecting water quality and temperature, providing wildlife habitat, screening structures and enhancing aesthetics, and providing access for recreation.

Vegetated Filter Strips and Level Spreaders - Uniformly graded vegetated surfaces (i.e., grass or close-growing native vegetation) located between pollutant source areas and downstream receiving waters or wetlands. A level spreader is usually located at the top of slope to distribute overland flow or concentrated runoff (see the maximum overland flow length guidelines above) evenly across the entire length of the filter strip.

Vegetated Roof Covers - Multilayered, constructed roof systems consisting of a vegetative layer, media, a geotextile layer, and a synthetic drain layer installed on building rooftops. Rainwater is either intercepted by vegetation and evaporated to the atmosphere or retained in the substrate before being returned to the atmosphere through transpiration and evaporation. Also referred to as green roofs.

Water Balance – Equation describing the input, output, and storage of water in a watershed or other hydrologic system.

Water Quality Flow (WQF) – The peak flow associated with the water quality volume calculated using the NRCS Graphical Peak Discharge Method.

Water Quality Swales - Vegetated open channels designed to treat and attenuate the water quality volume and convey excess stormwater runoff. Dry swales are primarily designed to receive drainage from small impervious areas and rural roads. Wet swales are primarily used for highway runoff, small parking lots, rooftops, and pervious areas.

Water Quality Volume (WQV) – The volume of runoff generated by one inch of rainfall on a site.

Watershed Management - Integrated approach addressing all aspects of water quality and related natural resource management, including pollution prevention and source control.

Xeriscaping - Landscaping to minimize water usage ("xeri" is the Greek prefix meaning "dry") by using plants that are adapted to the local climate and require minimal watering, fertilizer, and pesticide application, and improving soils by adding soil amendments or using mulches to reduce the need for watering by increasing the moisture retained in the soil.

Appendix G: Stoke's Law Derivation

Derivation of A = 120Q: Based on Stoke's Law, particles will settle in quiescent zone at a velocity that can be calculated using the equation A = 120Q. The settling area of the structure is adequate if it is greater than or equal to the area calculated by this equation.

This settling velocity (Vs) is dependent on the downward force of gravity, particle density in comparison to water, particle diameter (assuming a spherical shape) and water viscosity in the settling zone. Assuming that water is at 40^0 F and using equation $v_0 = (g(\square_s - \square)d^2)/18\square$, settling velocity for a particle of sand of diameter 0.00023 feet (i.e., 70 um) is 0.01 feet per second. This particle is called the reference particle.

For extended detention basin design, plug flow conditions are assumed to create a condition of relative quiescence where suspended particles (e.g., sand) match the velocity of water in the settling zone. Plug flow can be defined as an area where flow lines are parallel in three dimensions and of a constant velocity. Plug can also be defined as area where laminar flow occurs in all planes throughout the depth of flow at constant velocity. Where such conditions occur, particles of sand will drop out of suspension. Larger particles of the same and greater density will also drop out of suspension.

If settling velocity is set equal to velocity of flow in the settling area (i.e., Vs = Vo) then particles will settle out at a trajectory of 45^0 and will strike the bottom on the settling basin in the settling zone provided that its flow length equals or exceeds the depth. (This is also expressed as Vo = H/t, where H is particle height above the basin floor as the particle enters the settling zone; and t is time of particle residence in the settling zone.) Therefore, flow length must be greater than or equal to basin depth at the 2-year, 24-hour storm. Longest practicable flow lengths are preferred.

This is the same principle used to design wastewater settling basins and is discussed in *Unit Operations and Processes in Environmental Engineering* (Reynolds, 1982):

> Vo is the settling velocity of the smallest particle size that is 100 percent removed [i.e., Vo = Vs]. When a particle of this size enters the [settling] basin at [the surface of the water] it has a trajectory [of 45^0] and intercepts the [basin bottom] which is at the downstream end [of the basin]. The detention time is equal to the depth, H, divided by the settling velocity, Vo, or
>
> $$t = \frac{H}{Vo}$$
>
> The detention time, t, is also equal to the length, L, divided by the horizontal velocity, V, or
>
> $$t = L\,V^{-1}$$

The horizontal velocity, V, is equal to the flow rate, Q, divided by the cross-sectional area, HW, or

$$V = Q (HW)^{-1}$$

Combining equations…to eliminate V gives

$$t = L W H Q^{-1}$$

Equating [the] equations gives

$$L W H Q^{-1} = H Vo^{-1}$$

Rearranging yeilds

$$Vo = Q (LW)^{-1}$$

or

$$Vo = Q Ap^{-1}$$

where Ap is the plan area of the basin.

As extended detention basins are open to wind and operate in stormy conditions, a dimensionless constant of 1.2 should be added when calculating Ap (see Management Practices of Nonpoint Source Pollution Control [citation]. Therefore, Ap is calculated as:

$$Ap = 1.2 Q/Vo$$

Derivation of $Pl = 87.6Q^{1/2}$ *and* $Pl = 120Q/Ws + 7Ws$ *required pond are:* As expansion and contraction constants require adjusting the pond length based on the settling zone width, long, thin settling zones allow for the most efficient use of land. To account for unimpeded expansion and contraction during the 2-year, 24-hour storm, a pond's surface area (Ap) must equal the settling area (As) plus 2 times the settling area width (Ws) to account for expansion at a 4:1 ratio and 1.5 times the settling area width to account for contraction at a 3:1 ratio:

$$Ap = As + 3.5 Ws$$

Therefore, ponds tend to become significantly less efficient where width is greater than length.

A pond's length (Pl) is a function of its settling area length (Ls) plus its settling area width times 7.

$$Pl = Ls + 7\ Ws$$

If the desired width of a pond is known, for a pond where:

$$Q = As\ Vo/1.2$$

Pond length can also be calculated in relation to Q by substituting:

$$Ls = As/Ws \qquad \text{where Ls > depth of pond (e.g., 6 feet)}$$

which yields:

$$Pl = As/Ws + 7Ws$$

and substituting:

$$As = 120Q$$

which yields:

$$Pl = 120Q/Ws + 7Ws$$

If pond length is known, then width can also be calculated but requires, but requires rearrangement and conversion to the quadratic form, which results in the following

$$Ws = (Pl \pm (Pl^2 - 3360Q)^{1/2})/14$$

If the settling area is square (i.e., Ls = Ws and $Ws = As^{1/2}$), then substitute Ws for Ls in the equation:

$$Pl = 8As^{1/2}$$

Then:

$$Pl = 8Ws$$

And substituting 120Q for As, yeilds:

$$Pl = 8(120Q2)^{1/2} \text{ or } Pl = 87.6Q^{1/2}$$